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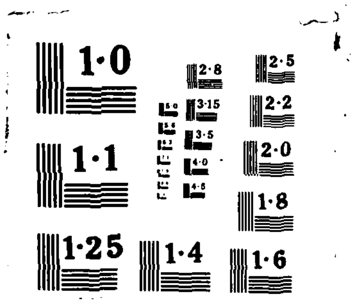
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THE ARCHAEOLOGICAL POTENTIAL OF POOL NO. 10,
UPPER MISSISSIPPI RIVER:
A GEOMORPHOLOGICAL PERSPECTIVE

by
Peter E. Church

Prepared for the
US Army Engineer District, St. Paul

Conducted by
Geotechnical Laboratory
US Army Engineer Waterways Experiment Station
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A geomorphic investigation of Pool No. 10 on the Upper Mississippi River at Guttenberg, Iowa, was conducted to identify potential locations of prehistoric cultural resources. The geomorphic maps delineate areas of high and low potential of containing archaeological sites and can serve as a practical guide having great utility for a comprehensive cultural resource survey. Since the estimation of archaeological potential is bases on landform stability through time, the geomorphic maps also have important engineering applications.

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ABSTRACT

A geomorphic investigation of Pool No. 10, Upper Mississippi River valley, was conducted to identify potential locations of prehistoric cultural resources. Landforms having high and low potential of containing archaeological sites were differentiated on the basis of process of formation and relative stability through time and were delineated on a series of geomorphic maps. Definition and delineation of specific landforms of the study area were based on interpretation from pre- and post-lock and dam aerial photographs, topographic maps, borehole logs, and field investigation.

The Upper Mississippi River in the area of Pool No. 10 has experienced several episodes of aggradation and degradation in the past approximately 22,000 years related to the advance and retreat of lobes of the late-Wisconsinan ice sheet. The net effect of these events was to partially fill the deep bedrock valley of the Upper Mississippi River with thick deposits of gravelly sand outwash. Late-Glacial and early Post-Glacial drainage of glacial lakes through the Upper Mississippi Valley caused deep incision and erosion of the outwash deposits and the formation of terraces. Entrenchment by relatively sediment free water from glacial lakes produced a valley floor profile with a gentle downvalley gradient. Aggradation of silt and sand contributed from tributary rivers has occurred on this gently sloping valley floor during the Holocene. Accumulation of sediment is concentrated near the junctions of major tributaries having high sediment loads. Stable anastomosing channel patterns have developed in reaches upstream from these tributaries, whereas, relatively unstable braided channel patterns have developed in downstream reaches. Lateral accretion of sandy channel bars and subsequent vertical accretion of silt and clay have been the dominant processes building the floodplain of the anastomosed reaches. Burial of eroded terrace outliers by the vertical accretion of silt and clay has been important locally.

This understanding of the geomorphic development of Pool No. 10, in conjunction with existing archaeological data, has allowed the archaeological potential of Pool No. 10 landforms to be estimated. The geomorphic maps delineate areas of high and low potential of containing archaeological sites and can serve as a practical guide having great utility for a comprehensive

cultural resource survey. Since the estimation of archaeological potential is based on landform stability through time, the geomorphic maps also have important engineering applications.

PREFACE

This investigation was authorized by the U. S. Army Engineer District, St. Paul, Corps of Engineers, on DA Form 2544, No. NCS-IA-82-105-PD-ER, "Geomorphological Study of Pool 10, Upper Mississippi River Basin," dated 30 August 1982.

The investigation was performed during the period 1 February 1983 to 15 March 1984 under the direct supervision of Dr. Lawson M. Smith, Chief, Regional Studies Unit, and under the general supervision of Mr. John H. Shamburger, Chief, Engineering Geology Applications Group (EGAG), Dr. Don C. Banks, Chief, Engineering Geology and Rock Mechanics Division (EGRMD), and Dr. William F. Marcuson III, Chief, Geotechnical Laboratory. The investigation was performed and the report prepared by Mr. Peter E. Church with the assistance of Dr. Lawson M. Smith and the consultation of Dr. Roger T. Saucier, Environmental Laboratory, WES.

The Commander and Director of the WES during the conduct of the investigation and preparation of the report was COL Tilford C. Creel, CE. The Technical Director was Mr. Fred R. Brown.

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PART I: INTRODUCTION

Background

This study was made in response to a request for a geomorphic study of Pool No. 10, Upper Mississippi River, from the U. S. Army Engineer District, St. Paul (NCSPD-ER) to the U. S. Army Engineer Waterways Experiment Station. Maintenance of a navigable channel in Pool No. 10 requires that the cultural resources of the area be evaluated to determine the potential impact of channel maintenance activities. A geomorphic study was requested so that potential locations of cultural resources (archaeological sites) could be identified and the environmental setting of those sites could be described.

Objectives

The objectives of this investigation include: (a) interpretation of the geomorphic development of the Pool No. 10 area, (b) determination of the relationship between the geomorphic development of the Pool No. 10 floodplain and the location of archaeological resources, and (c) determination of the potential of locating archaeological sites on specific landforms within the Pool No. 10 floodplain. A regional perspective is necessary in order to understand the geomorphic development of the study area (objective a) and to establish the physical context of archaeological resources. This regional perspective will allow the more site-specific conclusions (objectives b and c) to be applied to other sections of the Upper Mississippi River.

Scope

The geomorphic investigation was concentrated on the Upper Mississippi valley in the vicinity of Pool No. 10 (Figure 1). This reach of the Mississippi River extends approximately 34 river miles downstream from Lock and Dam No. 9, about 3 miles south of Lynxville, Wisconsin, to Lock and Dam No. 10 at Guttenberg, Iowa. The following interpretation of the geomorphic development of Pool No. 10 includes a much larger area while identification of associations between landforms and archaeological sites focuses on the floodplain of Pool

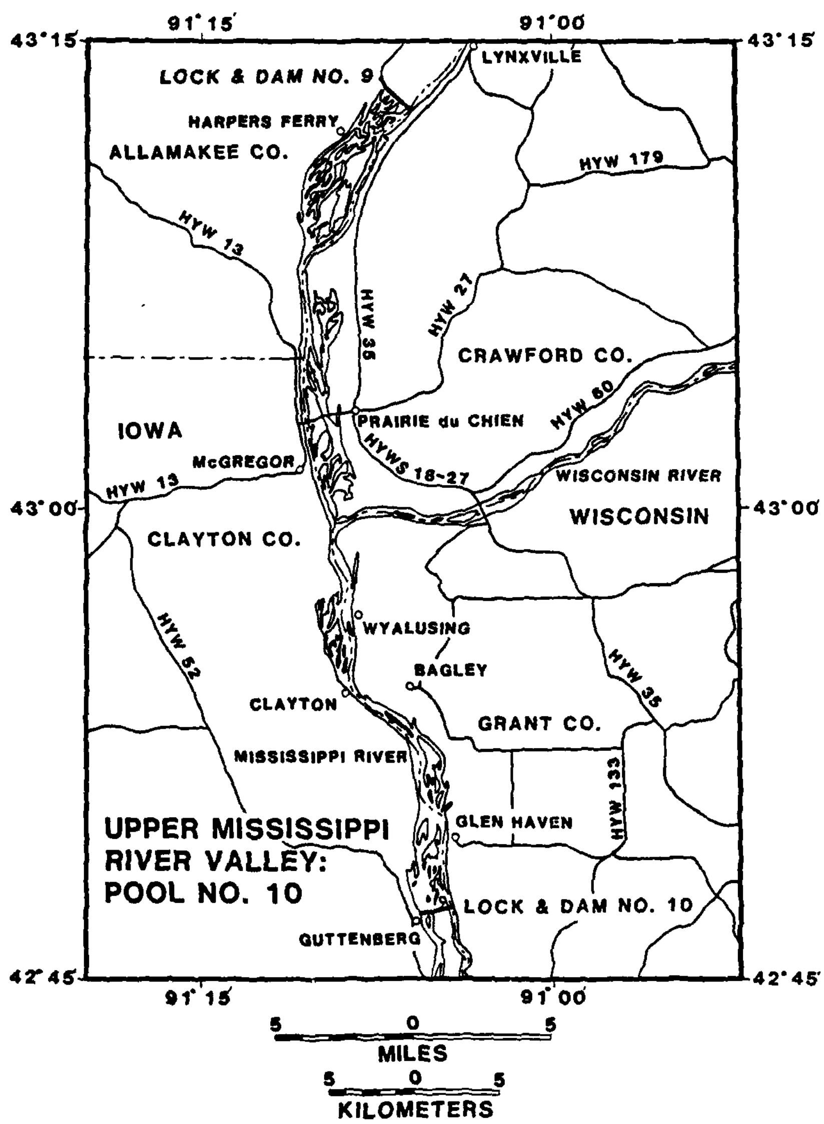


Figure 1. Pool No. 10 Area, Upper Mississippi River valley

No. 10. The floodplain includes all area that lies between the valley walls and below the terraces surfaces (Figure 2).

Limitations of Present Study

During this investigation an attempt was made to extract the greatest amount of geomorphic information of possible utility to the archaeologist from available data sources and from a limited amount of field work. Certain limitations are inherent in these data sources and they need to be identified at the outset. It must be emphasized that interpretation of the landforms in the Pool No. 10 area was done from aerial photographs and reconnaissance field inspection and survey. Chronological control of the development of the Mississippi floodplain is based on only a few archaeological site affiliations and extrapolation to other areas involves some uncertainty. The existing archaeological dates span only about one-third of Holocene time leaving the early development of the floodplain unclear. Borehole data available for the Pool No. 10 area are insufficient in quantity and detail to permit more than a generalized knowledge of the stratigraphy of the alluvial fill in the Mississippi valley. Late-Glacial and early Post-Glacial development of the valley fill and terraces is, to a large degree, based on the presumed impact of glacial and deglacial events upstream and not on detailed sedimentologic and stratigraphic studies. Until more extensive field investigation is conducted, the conclusions drawn in this report regarding the chronology of formation of the Mississippi floodplain and other geomorphic features of the Pool No. 10 area must be considered working hypotheses.

Historical Floodplain Modifications

This study is primarily concerned with the prehistoric geomorphic development of the Pool No. 10 area, however, historic modifications of the floodplain need to be described. The Upper Mississippi River and basin have experienced significant changes since European settlement of the Upper Midwest. Clearing of large tracts of land for agricultural purposes in the middle and late nineteenth century has resulted in an accelerated rate of upland soil erosion and floodplain sedimentation. Alluviation of floodplains with silt

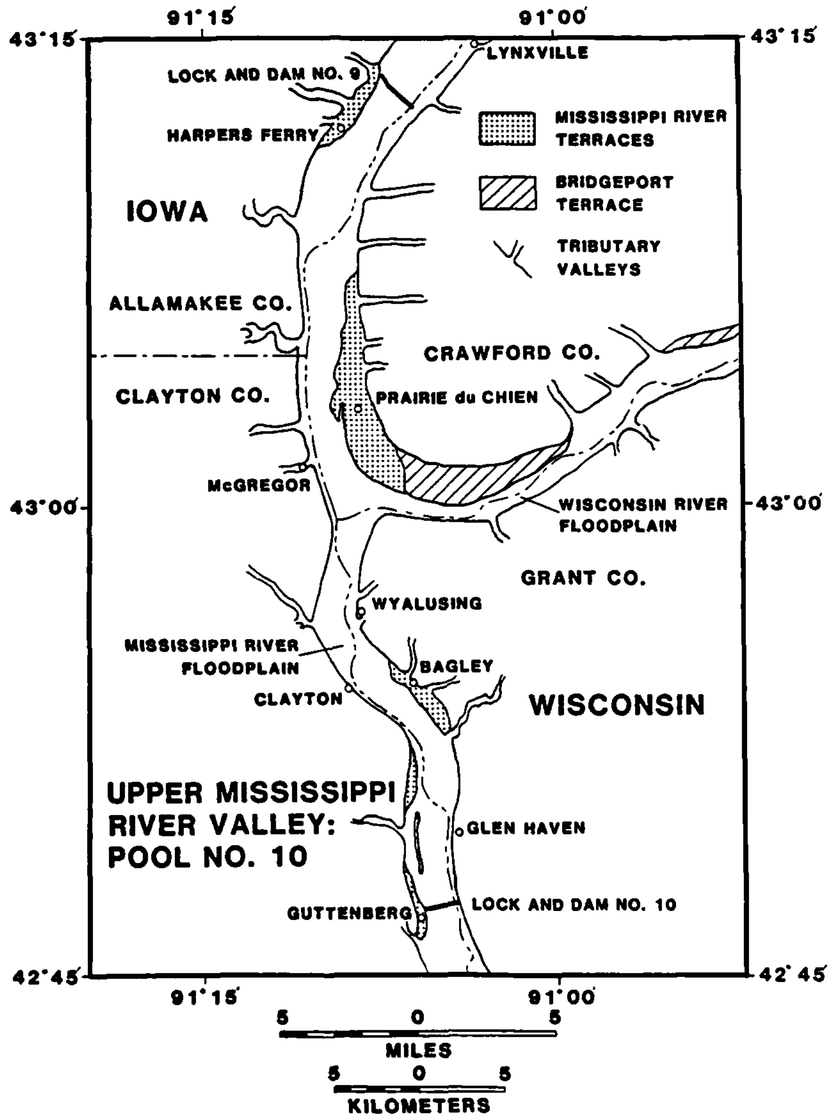


Figure 2. Map of terraces and floodplain in the Pool No. 10 area

eroded from hillslopes has been substantial in tributary streams of the Mississippi River in the vicinity of Pool No. 10 (Happ, 1944; Knox, 1972). Historic sedimentation has been less on the Mississippi River floodplain, however, a veneer of historic silt, variable in thickness, does mantle much of the exposed land in the Mississippi floodplain. The thickness of this veneer has not been well documented. Boszhardt and Overstreet (1983) reported a 1 to 3 meter (3.3 to 9.8 ft) range in thickness of historic sediment on islands in Pool No. 12 near Dubuque, Iowa. The areal distribution of this historic sediment on the floodplain of the Upper Mississippi River has not been investigated.

In the late nineteenth and twentieth century, developments in the Pool No. 10 area included the clearing of snags and the building of dikes and wing dams to control the river position. In the 1930's Lock and Dam No. 10 was constructed to maintain a sufficient depth for navigation. Water levels were raised approximately 2 ft above the 1930 low water stage at the upper end of the pool and approximately 10 ft at the lower end of the pool. Examination of a sequence of maps and aerial photographs, dating from the mid-nineteenth century to the present, has revealed that the major features of the floodplain have changed little in the past approximately 150 years. Islands and channels are in essentially the same configuration now as they were at the time of European settlement. The most significant changes observed were related to sedimentation along wing dams and inundation of formerly exposed land by Pool No. 10.

This report attempts to interpret the prehistoric chronology of floodplain evolution and is not directly concerned with historic floodplain modifications. However, historic changes were analyzed to the extent that they lend insight into prehistoric processes and have implications for archaeological investigations. Reports that deal with historic floodplain processes and changes on the Upper Mississippi River include Cawley (1973), Chen and Simons (1979), GREAT I (1980), Nakato (1981), Simons et al. (1975), and Simons et al. (1976). References to the Mississippi River and floodplain in this report will be understood to mean the pre-lock and dam river and floodplain unless otherwise indicated.

PART II: QUATERNARY GEOMORPHIC HISTORY OF THE POOL NO. 10 AREA

Introduction

The Upper Mississippi valley encompasses a large area that has experienced a complex series of geological events since the beginning of the Quaternary Period.* Many of the present-day landforms in this region are relict from the multiple episodes of continental glaciation that occurred during the Quaternary. In recently glaciated areas the topography consists of low rolling hills with poorly defined drainage networks and many lakes and poorly drained depressions. Areas not subject to the most recent glaciations have drainage networks that are better defined and have fewer lakes and poorly drained depressions. Local relief is generally greater in the areas where recent glaciation has not occurred and is primarily the result of stream incision into the older glacial deposits. The upland area in the Pool No. 10 region, including southwestern Wisconsin and adjacent portions of Illinois, is not believed to have been glaciated during the Quaternary Period and is referred to as the "Driftless Area." Stream erosion has created a well developed drainage network with steep valley side slopes and high relief. The local bedrock of relatively flat lying upper Cambrian sandstone and siltstone and Ordovician cherty dolomite, sandstone, and limestone is exposed frequently on the valley walls (Figure 3).

The Upper Mississippi River originates on the late Pleistocene till plains of northern Minnesota, flows along the Driftless Area on Wisconsin's western border, and then flows southward through the older till plains of western Illinois and southeastern Iowa. The Pool No. 10 area is located on that portion of the river flowing along the Driftless Area (Figure 4). Pleistocene glaciations largely determined the present-day course and gradient of the valley through shaping of the bedrock surface, deposition of glacial sediments, and deflection of the Mississippi River. The modern channel and floodplain are inset within outwash deposits (terraces) derived from these

* The Quaternary Period includes the time period of continental glaciation in North America and Europe, the Pleistocene (two or three million years to approximately 10,000 years before present (B.P.)), and the time period since continental glaciation, the Holocene (10,000 years B.P. to the present).

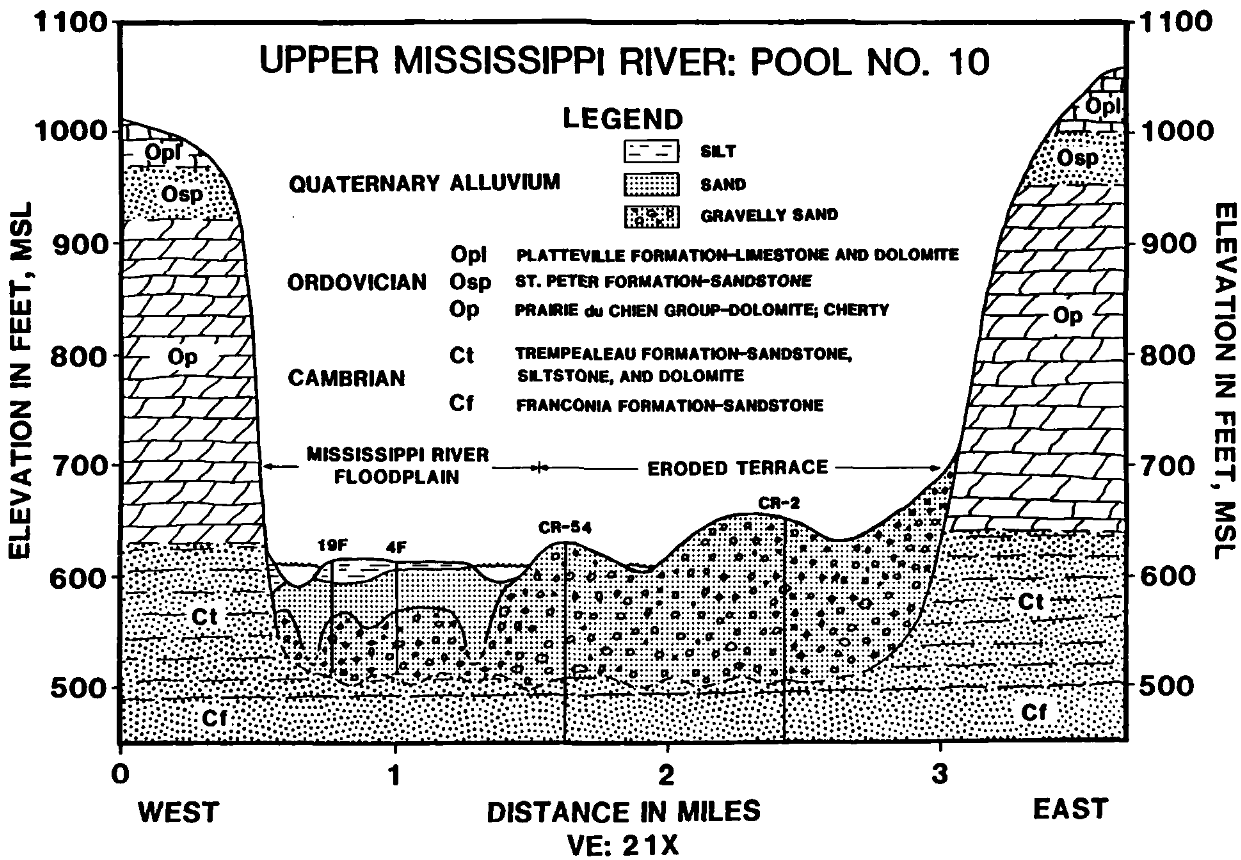
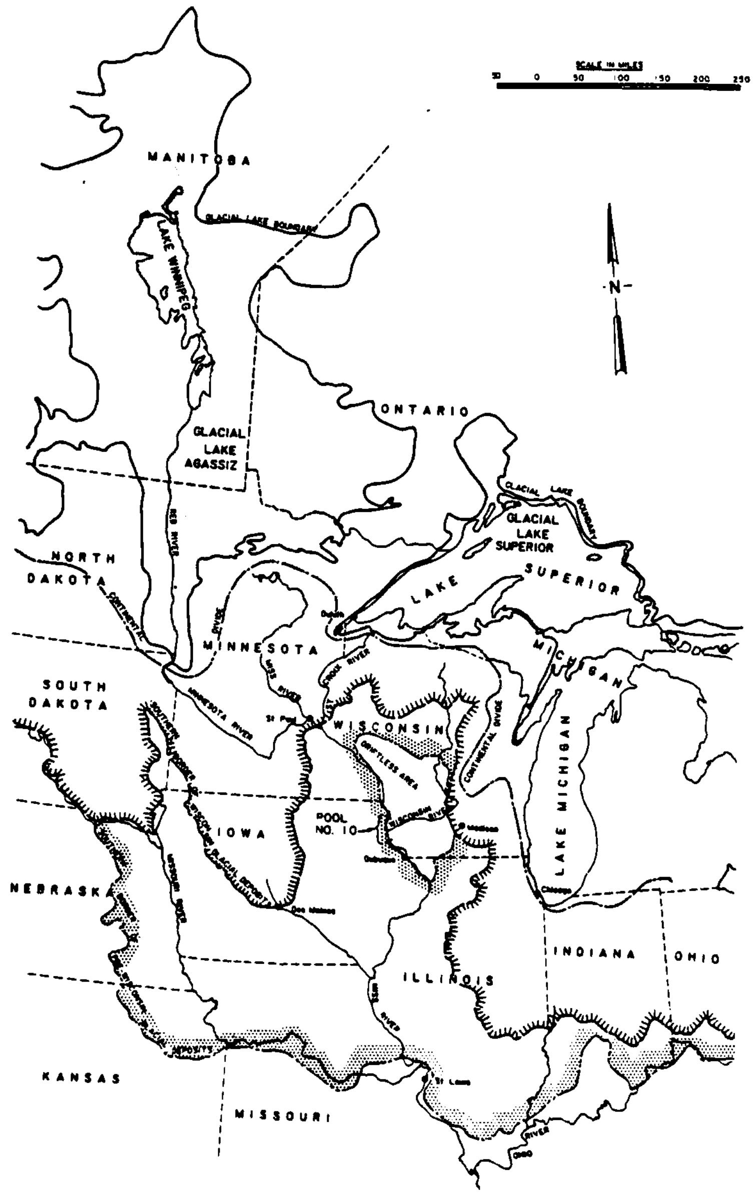


Figure 3. Generalized cross section through the Upper Mississippi valley near Prairie du Chien, Wisconsin



GLACIAL MAP OF UPPER MIDWEST

Figure 4. Map displaying distribution of Pleistocene glacial deposits and maximum areal extent of glacial Lakes Agassiz and Superior (map adapted from Flint, et al., 1949)

glaciers. Therefore, an understanding of the history of the development of the valley is essential to the understanding of the behavior of the current channel and floodplain in the Pool 10 area. Knowledge of the evolution of the Pool No. 10 channel and floodplain will enable the archaeological potential of the present-day landforms to be assessed.

Early Pleistocene Valley Development

The bedrock valley of the Upper Mississippi River along the Iowa-Wisconsin border was formed as a result of pre-Illinoian geological events.* Major valley incision and channel development in the central interior United States was initiated during the early Pleistocene and was associated with broad regional crustal upwarping (Frye, 1973). The Upper Mississippi River at that time was located approximately 100 miles west of its present position along the Iowa-Wisconsin border (Trowbridge, 1954). Advance of the "Nebraskan" glacial ice over northeastern Iowa 2.5 to 3 million years before present (B.P.) resulted in displacement of the Mississippi River from that location to its present position (Trowbridge, 1954, 1966; Frye, Willman and Black, 1965; Willman and Frye, 1969, 1970). Subsequent glaciations have further modified the course of the Upper Mississippi River valley in southeastern Iowa and in Illinois, however, the course of the valley in Wisconsin has not changed since the "Nebraskan Age." Deep incision of the valley is thought to have occurred early in the "Kansan Age" (Frye, Willman and Black, 1965; Frye, 1973). The valley floor was deepened to approximately 400 ft below the upland surface to the level of the bedrock terrace located at the mouth of the Wisconsin River at Bridgeport, Wisconsin (Trowbridge, 1954) (see Figure 2). Glacial deposits believed to be "Kansan" in age are found on this terrace, supporting the early "Kansan" interpretation (MacClintock, 1922; Knox, Attig and Johnson, 1982). The valley was downcut another 200 to 300 ft to its maximum depth in

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* The most recent major period of Pleistocene continental glaciation in North America is referred to as the Wisconsinan Age. Other major glaciations in order of increasing age have classically been referred to as Illinoian, Kansan, and Nebraskan. These terms, especially Kansan and Nebraskan, are being used less and less as more is learned of the true complexity of the glacial ages. Therefore, the terms Kansan and Nebraskan appear in quotations throughout this report.

"post-Kansan" time (Trowbridge, 1954). Recent unpublished drilling data indicate that "pre-Kansan" incision was deeper than the level of the bedrock terrace at Bridgeport (Knox, 1983). Therefore, it is uncertain whether maximum entrenchment of the bedrock valley is "pre- or post-Kansan" in age. The great depth to which the valley was carved in this reach may be the result of incision of the Mississippi River through a region of crustal upwarping (a forebulge) caused by the weight of adjacent glacial ice at various time during the Pleistocene (Willman and Frye, 1969; Knox and Johnson, 1974). As the glacial ice retreated, the forebulge subsided to its former level, leaving a deep and narrow gorge through which the river now flows.

Late Pleistocene and Holocene Floodplain Development

Surface exposures of valley fill deposits in the Upper Mississippi River are primarily late-Wisconsinan (22,000 to 10,000 years B.P.) and Holocene in age. Older valley fill deposits may occur at depth, however, their presence has not been documented in the Pool No. 10 area. A generalized geologic cross section through the Upper Mississippi River valley in the area of Pool No. 10 displaying the valley fill is presented in Figure 3. This geologic cross section is based upon examination of borehole data from Lock and Dam Nos. 9 and 10, the U. S. Highway 18 bridge over the Mississippi River at Prairie du Chien, Wisconsin, and from other isolated drill logs in the Pool No. 10 area (on file at WES).

Association of the high alluvial terraces that occur below the Bridgeport surface in the Mississippi and Wisconsin River valleys with Woodfordian (a late-Wisconsinan glacial subage 22,000 to 12,000 years B.P.) terminal moraines implies that maximum alluviation of the valleys occurred after approximately 22,000 years B.P. (Frye, Willman and Black, 1965; Knox and Johnson, 1974). The history of the valley since that time was greatly influenced by the retreat of glacial ice and the formation and drainage of glacial Lakes Agassiz and Superior, along the United States-Canadian border (Figure 4). The chronology of these events has been most recently described by Clayton and Moran (1982) and Clayton (1983) and their presumed impact on the Mississippi River has been described by Clayton (1982). The following account is adapted from these papers as well as from Matsch and Wright (1967) and selected papers appearing in Teller and Clayton (1983).

Net aggradation of the Upper Mississippi valley with Woodfordian outwash gravels derived from the Red River and Superior Glacial Lobes in Minnesota is believed to have persisted until the ice retreated north of the continental divide about 12,200 years B.P. The subsequent formation of glacial Lakes Agassiz and Superior and the resultant flow of large quantities of relatively sediment free water down the Mississippi River through the Minnesota and St. Croix Rivers caused downcutting into the Woodfordian alluvium and the formation of terraces. Drainage of these glacial lakes may have been catastrophic as outlets were eroded. A brief readvance of the glacial lobes across the continental divide again introduced outwash into the Mississippi River causing a short period of aggradation from about 11,700 to 11,500 years B.P. Glacial Lakes Agassiz and Superior reformed after 11,500 years B.P. and spilled water into the Mississippi River drainage causing an episode of downcutting. This erosional episode lasted until about 10,800 years B.P. when continued retreat of ice opened lower elevation outlets for the lake water to the east. Another episode of augmented Mississippi River discharge and downcutting occurred from about 9,900 to 9,500 years B.P. when readvance of ice temporarily blocked eastern outlets for the glacial lake water. This episode is believed to be the last time the Upper Mississippi River north of central Illinois received water draining from glacial lakes.

Existing sedimentologic and geomorphic data are not adequate to distinguish all of these late-Wisconsinan events and, moreover, later episodes of glacial lake drainage may have removed evidence of their predecessors. However, examination of Figure 3 does lead to the following general conclusions. Glacial lake drainage caused downcutting into the alluvium deposited during the Woodfordian subage. Several isolated patches of Woodfordian alluvium remain in the valley as terraces (Figure 2). The surfaces of many of these terraces (for example at Prairie du Chien and Bagley, Wisconsin) exhibit erosional features suggesting the occurrence of catastrophic floods. Downcutting into the Woodfordian alluvium may have occurred rapidly during these flood events. Whether the gravels depicted on Figure 3 represent one stratigraphic unit, or if several Quaternary deposits are present is unknown. The gravels that occur beneath the floodplain below 560 ft to 570 ft in elevation are interpreted to be Woodfordian or older in age. However, their precise time equivalence with the gravels forming the terraces is uncertain because they may be the result of one or more cut and fill episodes. Nevertheless, their minimum Woodfordian age is implied because the decrease in river competence resulting from cessation of glacial meltwater input would have precluded the transport of appreciable quantities of gravel since that time. This interpretation is supported by the observation that the present Mississippi River sediment load in this region is restricted primarily to sand sized grains and finer (Nakato, 1981) in spite of the abundant supply of gravel in the terrace deposits.

A detailed geologic cross section across the floodplain was constructed from borehole data from the U. S. Highway 18 bridge at Prairie du Chien and is presented in Figure 5 (see Plate 3 for location). None of the 27 borings represented in this cross section penetrated through the valley fill into the underlying bedrock. Consequently, the depth to bedrock beneath the floodplain in Pool No. 10 is unknown. It is possible that the elevation of the bedrock floor beneath the floodplain is the same as that beneath the terrace (i.e., 500 to 510 ft) as is implied in Figure 3. However, the line delineating the top of gravelly sand alluvium on Figure 5 is interpreted as an erosional surface associated with late Woodfordian to early Holocene entrenchment. Therefore, the bedrock valley floor may occur at a lower elevation beneath the East and West Channels. This erosional surface is reflected in the present surface topography suggesting that the locations of the East and West Channels and Island 172 were determined as a result of this entrenchment. A linear depression on the western half of Island 172 is also reflected in the subsurface topography of the gravelly sand alluvium. This evidence indicates that many large-scale geomorphic features of the present floodplain are surface reflections of the underlying late Woodfordian erosional surface. In addition, the eroded surface of the adjacent terrace of Woodfordian alluvium and the erosional surface beneath the floodplain are contemporaneous and continuous (see Figure 3). Aggradation since the last influx of glacial meltwater (approximately 9,500 years B.P.) has buried the lower portions of this erosional surface. The depth of burial varies from approximately 40 ft beneath Island 172 to greater than 100 ft beneath the East and West Channels. Some of this filling may have occurred rapidly during recession of the meltwater floods. The amount of fill representing slow more continuous alluviation during the Holocene is unknown. However, it is likely that the upper 40 ft (the depth of

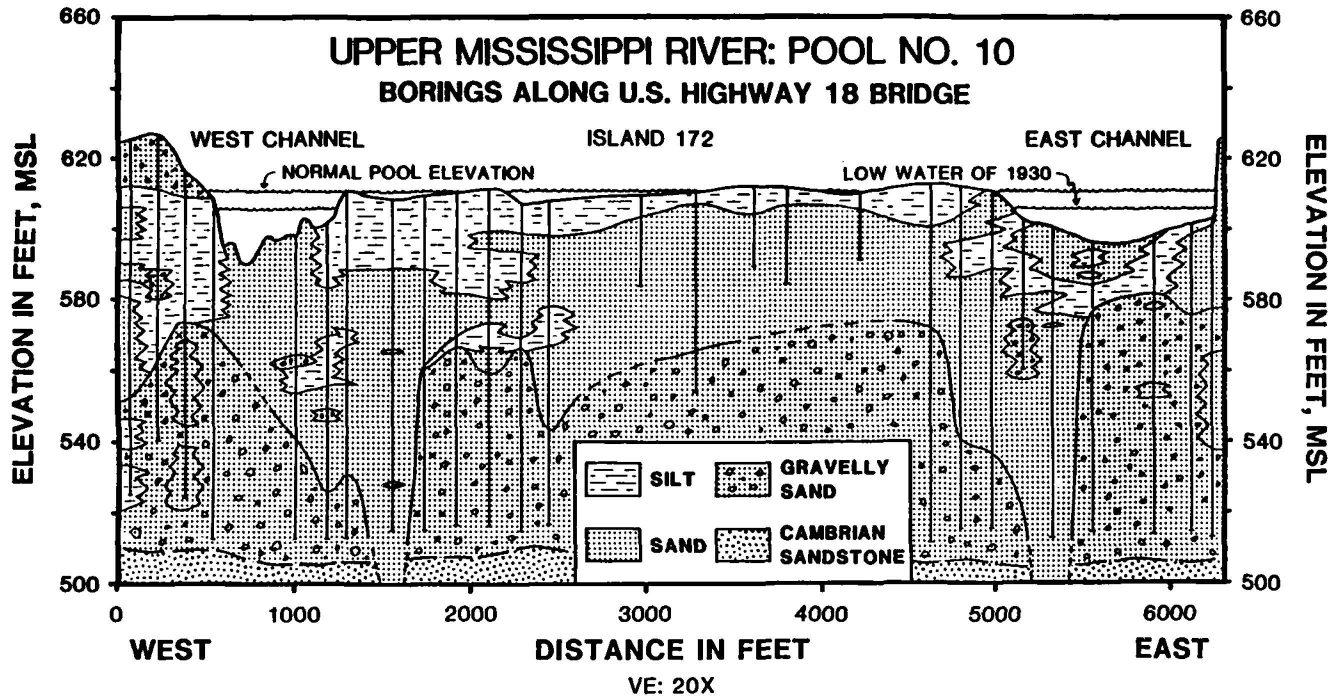


Figure 5. Geologic cross section across the Mississippi Floodplain along Highway 18 at Prairie du Chien, Wisconsin

burial beneath Island 172) represents Holocene sedimentation. Examination of Figure 2 of Knox and Johnson (1974) indicates that 40 ft of Holocene alluviation in Pool 10 is reasonable. Their figure displays the longitudinal profile and the depth to gravels in the Big Platte River, a tributary to the Mississippi River in Pool No. 11 north of Dubuque, Iowa. Approximately 30 ft of Holocene alluviation near the mouth of the Big Platte River is indicated. Holocene alluviation at the mouth of the Chippewa River upstream in Pool No. 4 is estimated to be as much as 50 to 60 ft (Andrews, 1965).

Seismic survey results from along McGregor Lake (conducted by Donohue Engineers and Architects, Milwaukee, Wisconsin, in November 1983, and reported in Overstreet, 1984), located just south of the boring transect on Figure 5, indicate the presence of three distinct subsurface layers. The first layer, from 0 to 14.4 ft, was interpreted to be a loose silty soil. Gravelly alluvium was inferred from a depth of 14.4 ft to 80 ft. Beneath a depth of 80 ft the material was interpreted to be weathered sandstone. Comparison with the detailed boring information presented on Figure 5 indicates that the depths to interfaces are reasonable but the material identifications are suspect. Reevaluation of the seismic survey results may reveal that the layer from the depth of 14.4 ft to 80 ft is a firm sand and the layer beneath 80 ft is a gravelly sand. It is unlikely that weathered sandstone occurs at a depth of 80 ft at this location because it was not encountered in any of the 20 nearby borings that penetrated below that depth. If the depth to gravelly alluvium at McGregor Lake is 80 ft, McGregor Lake may overlie a channel or scour pool carved into the Woodfordian alluvium.

The development of the landforms of the present floodplain surface is largely a result of geomorphic activity during the Holocene. However, this activity has been and still is greatly influenced by geomorphic features inherited from the Pleistocene. Net aggradation during the Holocene is believed to be a direct result of the gentle valley floor gradient produced by late Woodfordian to early Holocene entrenchment. Introduction of large quantities of outwash gravels during the glacial ages created the thick valley fill deposit with a relatively steep downvalley gradient. Figure 6 displays a longitudinal profile of the terrace surfaces in Pool No. 10. The eroded and discontinuous nature of the terrace surfaces in Pool No. 10 precludes terrace correlation and determination of downvalley gradients. However, examination

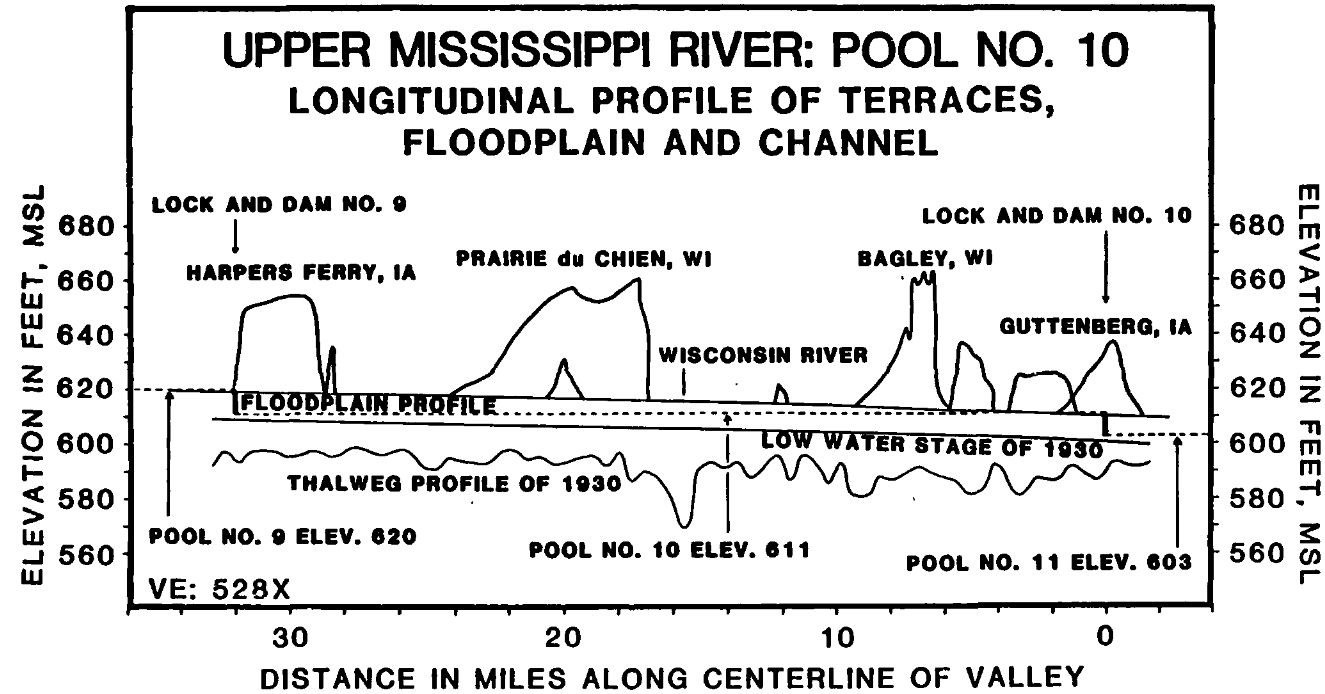


Figure 6. Longitudinal profiles of terrace surfaces, floodplain, channel and thalweg in Pool No. 10 (channel and thalweg profiles based on 1930 data (USACE, 1929-1930))

of terrace surface elevations upstream towards St. Paul, Minnesota, and downstream toward Dubuque, Iowa, reveals that the downvalley gradient of the terrace surfaces is considerably steeper than the gradient of the present floodplain (Martin, 1965). Alluvial terraces become more numerous, are higher above the floodplain, and have steeper downvalley gradients upstream toward St. Paul. The contribution of postglacial isostatic rebound to this phenomena is unknown, however, it is certain that transport of the outwash gravel underlying the terrace surfaces would have required relatively steep gradients. As can be seen on Figures 6 and 7, the downvalley gradient of the present floodplain is very gentle. The average slope of the valley floor between St. Paul and Dubuque, a distance of nearly 250 miles along the valley, is approximately 5 in. per mile. This slope is the most gentle valley gradient found along the entire Upper Mississippi River and is more gentle than a large portion of the Lower Mississippi valley as well (Figure 7). The gentle slope of the valley floor of the Upper Mississippi River in this region is primarily a result of entrenchment into the Woodfordian alluvium by the large quantities of relatively sediment free water draining from glacial Lakes Agassiz and Superior between 12,200 and 9,500 years B.P. Aggradation during the Holocene by sediment contributed from tributary rivers has further modified this inherited valley gradient to produce the present valley floor.

Drainage of the glacial lakes through the Mississippi Valley also produced significant depositional features, some of which require a catastrophic flood hypothesis to explain their origin. Slack water deposition in the Mississippi valley and in and near the mouths of tributary valleys occurred during the large floods. The resultant deposits range in grain size from gravelly sand to clay. Cross-bedded sand and gravelly sand dipping upvalley are found in at least one of these tributary valley terrace deposits (at Mill Coulee near Prairie du Chien). Similar sedimentologic features were described by Baker (1973) in eastern Washington and were associated with catastrophic flooding related to the sudden drainage of glacial Lake Missoula. Relatively thin layers of gray and red clay occur in the Woodfordian terrace deposits in the Mississippi valley and in the tributary valleys. Some of this clay is colluvial in origin, however, much of it represents slack water deposition from large floods. Flock (1983) has convincingly traced the origin of this slack water clay to source regions in the Agassiz and Superior Basins north of the

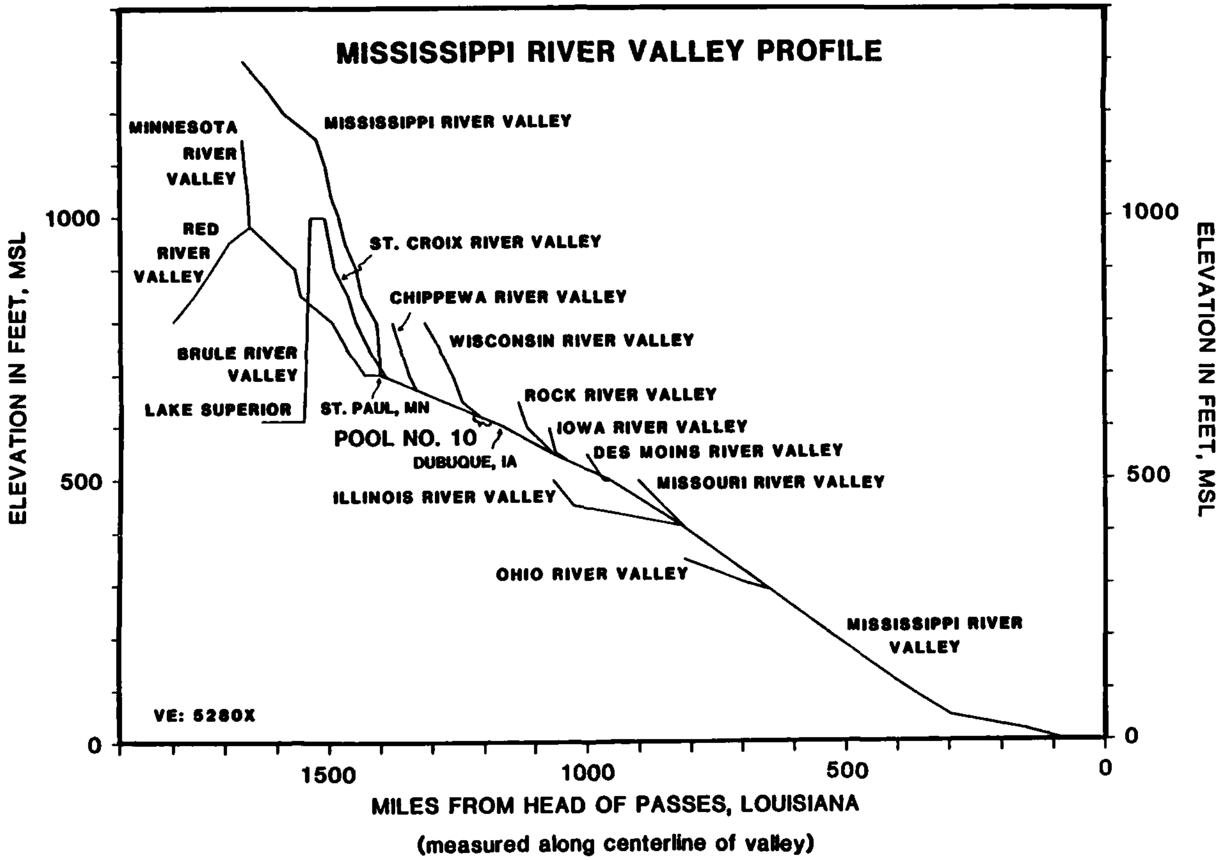


Figure 7. Longitudinal profile of Mississippi River valley from headwaters to mouth and valley profiles of lower reaches of major tributaries (profiles of glacial lake outlets to the Mississippi River are also indicated)

continental divide (Figure 4). Deposition of this clay must have occurred prior to 9,500 years B.P. and its positive identification allows it to be used as a chronologic marker horizon.

The formation of the present channel and floodplain of the Upper Mississippi valley in the Pool No. 10 area began with the cessation of floods from the glacial lakes about 9,500 years B.P. Since that time the flow of water and the influx of sediment has been small compared to the discharge and sediment loads of the preceding glacial periods. Aggradation of sand and silt contributed from tributary valleys and the formation of a complex pattern of channels, islands, and lakes have been the dominant geomorphic activities during the Holocene. The gentle gradient of the valley floor inherited from the large floods has resulted in the preferential accumulation of sediment at the junctions of major tributaries. Holocene floods have been unable to assimilate all of the sediment introduced at these locations. In reaches upstream from major tributaries (for example, the area north of the mouth of the Wisconsin River) the accumulation of sediment has resulted in very low valley gradients and the formation of stable anastomosing channel patterns. An extreme example of this process is found upstream from the confluence of the Chippewa River near Pepin, Wisconsin. Sediment introduced from the Chippewa River effectively dams the Mississippi River to form a lake over 20 miles long (Lake Pepin). In reaches downstream from major tributaries the accumulation of sediment has resulted in moderate steepening of valley gradients and the formation of unstable braided channel patterns. The interpreted history of the Upper Mississippi River in Pool No. 10 through the Holocene is described in greater detail in Part III.

PART III: GEOMORPHIC MAPS AND INTERPRETATION OF HOLOCENE FLOODPLAIN EVOLUTION

Introduction

In order to assess the archaeological potential of the landforms of the floodplain of the Upper Mississippi River in Pool No. 10 it is important to understand the evolution of these landforms. As described in Part II, the landforms of the floodplain are primarily Holocene in age. However, a complete chronology of Holocene events supported by absolute dates does not exist for the Upper Mississippi River. Nevertheless, a preliminary scenario has been reconstructed from available data. Interpretation of the development of the floodplain was accomplished by examining the spatial distribution of landforms from geomorphic maps constructed for this study and from analysis of sediment cores collected in the field. Analysis of existing archaeological data (diagnostic sites) allowed the ages of some of the landforms to be determined. Construction and interpretation of the geomorphic maps, analysis and interpretation of the field data, and a generalized Holocene history of floodplain evolution are presented below.

Construction of Geomorphic Maps

A series of maps at a scale of 1:24,000 depicting the geomorphic features found in the Pool No. 10 area of the Upper Mississippi River were constructed and are presented as Plates 1-7 (an index to Plates 1-7 is given in Figure 8). Interpretation of the geomorphic features was accomplished primarily from the examination of five series of black and white aerial photographs. The dates of the photographs span the years from 1927 to 1961 and range in scale from 1:13,200 to 1:20,000. Since the goal of this study was to investigate the natural (pre-lock and dam) environment of the Pool No. 10 area, emphasis was placed on analysis of the series of aerial photographs made in 1927. Pre-lock and dam maps, at a scale of 1:12,000 drafted from the 1929-30 survey of the Upper Mississippi River (USACE, 1929-1930), were used as base maps for the photo interpretation. With the use of a Zoom Transfer Scope, images of the photographs were projected at a scale of 1:12,000 onto transparent overlays covering the base maps. Geomorphic features were then interpreted and

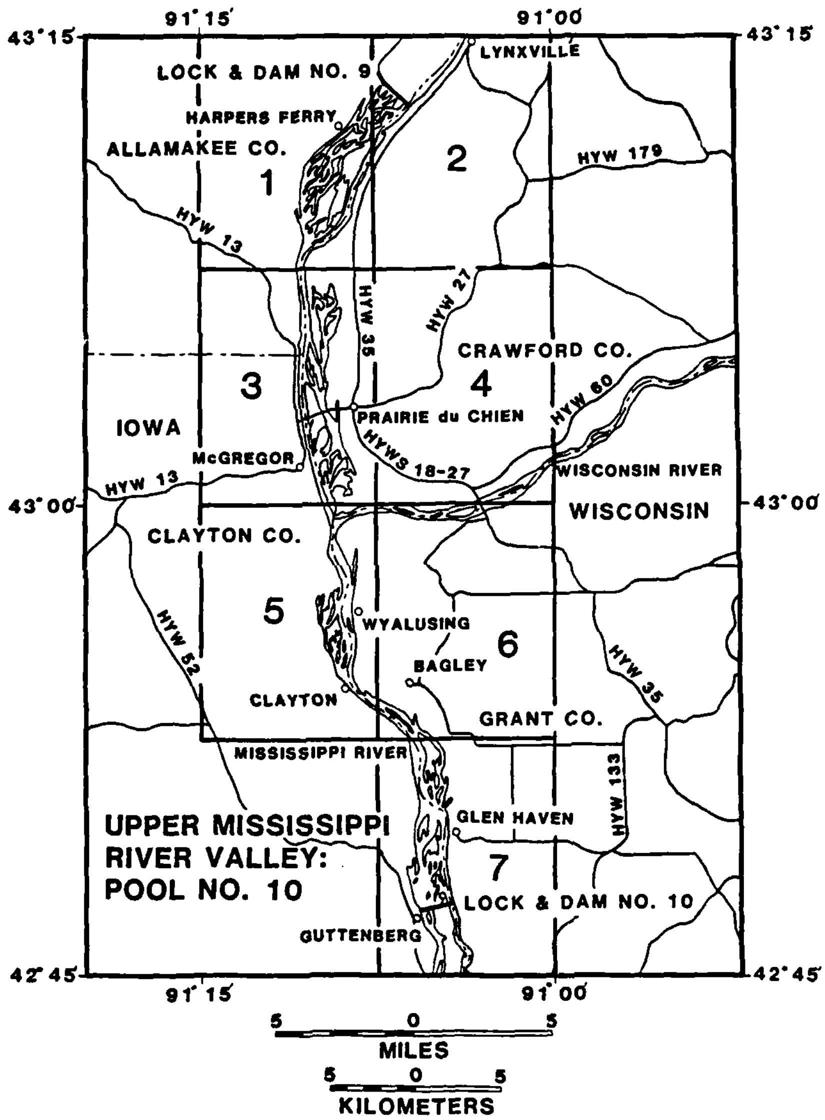


Figure 8. Index to Plates 1-7

delineated directly on the overlays. Production of the final geomorphic maps was accomplished by photographic reduction of the overlays superimposed on the base maps and transferred to the most recent topographic maps at the scale of 1:24,000. Field verification of the mapping was performed and is implicit in the discussion of the map units below.

Figures 9a and 9b are presented as an example of the aerial photographic interpretation of the landforms in Pool No. 10. Figure 9b shows the same area as 9a but has the landforms delineated. This area is located approximately two miles south of Harpers Ferry, Iowa (Plate 1) and contains some of the geomorphic features displayed on Plates 1-7 and described in the following paragraphs. The photograph used in Figures 9a and 9b postdates the closure of Lock and Dam No. 10 and, consequently, shows a larger water surface area than is indicated by the geomorphic map.

Description of Map Units

Definition and delineation of the geomorphic features were based on a classification system of the landforms in the Pool No. 10 area developed for this study. The following paragraphs describe the geomorphic features mapped and the processes responsible for their formation. This section has been divided into two parts based on the relative position of the landforms within the Pool No. 10 area. Geomorphic features of tributary valleys are discussed first followed by those located within the main valley of the Upper Mississippi River. Subsequent sections of this report discuss the chronology of development of the floodplain features within the main valley and their archaeological potential.

Tributary valleys

The steep walls of the Upper Mississippi Valley are interrupted at numerous locations by the entrance of tributary streams. With the exception of the Wisconsin River, a major tributary, all tributary streams in the Pool No. 10 area are small in comparison to the Mississippi River. Downcutting of the Mississippi River during the Pleistocene has caused tributary streams to incise their valleys. The tributary streams could not downcut at a rate sufficient to keep pace with downcutting of the Mississippi River and as a consequence their bedrock floors now possess relatively steep longitudinal

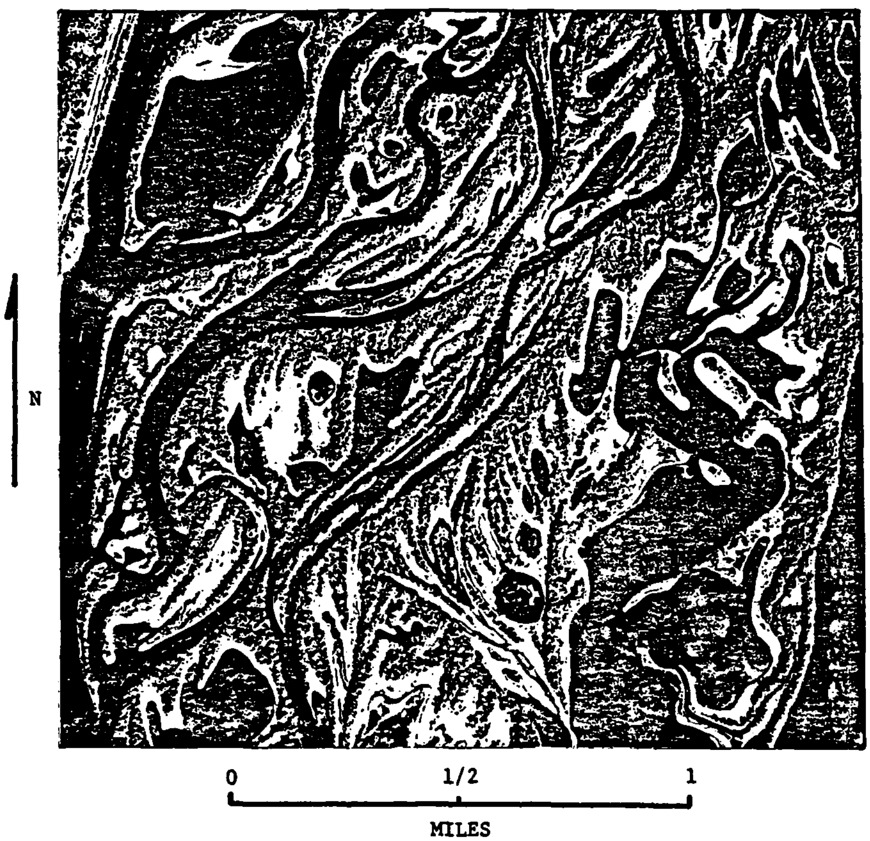
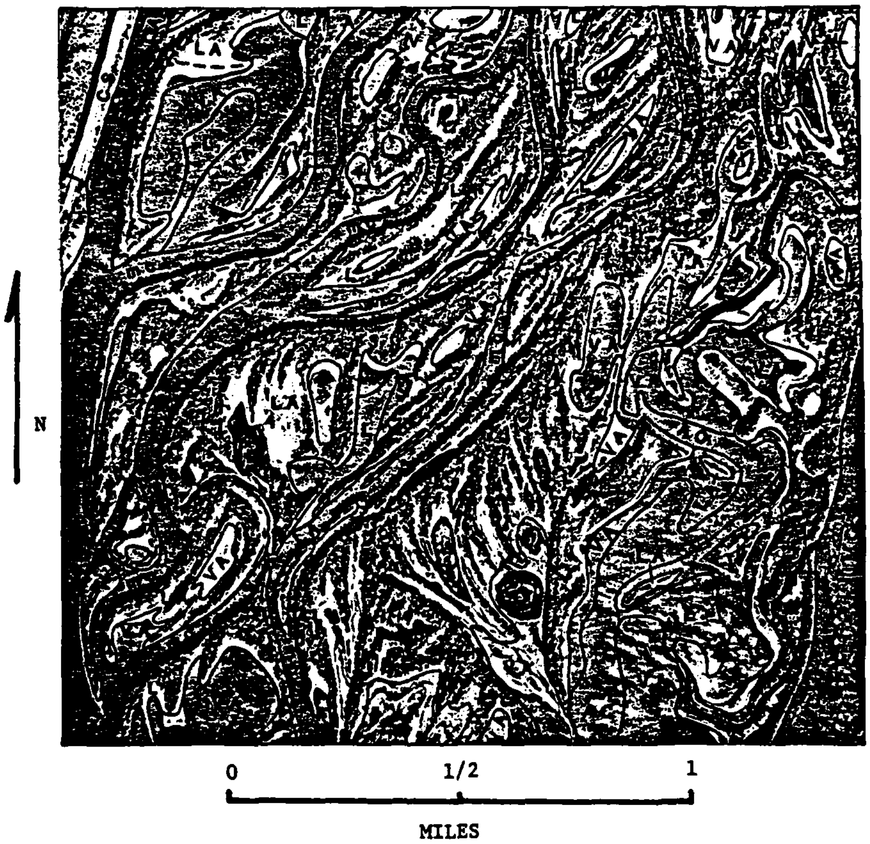


Figure 9a. Aerial photograph of a porticn of Plate 1 approximately 2 miles south of Harpers Ferry, IA



▬▬	Valley Wall	AC	Abandoned Channel
CS	Colluvial Slope	LA	Lateral Accretion Deposit
AF	Alluvial Fan	- - - -	Lateral Accretion Ridge
MC	Major Channel	VA	Vertical Accretion Deposit
mc	Minor Channel	L	Lake

Figure 9b. Same photograph as in Figure 9a with the geomorphic features delineated and identified

gradients. Fluvial activity in tributary valleys was also greatly influenced by the Woodfordian aggradational and degradational episodes in the Mississippi River Valley. Specific geomorphic features located within tributary valleys are discussed below.

Tributary terraces. Many isolated remnants of terraces are present in the tributary valleys (e.g., Plate 1, Sec. 13, T97N, R3W). Elevations of the tributary terrace surfaces range from 640 ft to 700 ft above sea level, or 30 ft to 90 ft above the present Mississippi River floodplain. These surfaces represent former tributary valley floodplains now abandoned because of late Woodfordian to early Holocene downcutting in the Mississippi valley. The ages of the various deposits underlying the terrace surfaces are unknown but most probably correlate with the Woodfordian aggradational episode (22,000 to 12,000 years B.P.) in the main valley. Entrenchment of the Mississippi Valley alluvium by relatively sediment free discharge from glacial lakes caused downcutting and terrace formation in the tributary valleys. Deposits in the terraces near the tributary mouths are in part the result of slack water deposition during late glacial catastrophic flooding. The internal sedimentology and depositional structure of the terrace deposit at the mouth of Mill Coulee, near Prairie du Chien, provide an excellent example of this process. In other cases, terrace deposits in the tributaries appear to represent a response to a rising base level at the tributary mouths as the Mississippi Valley was alluviated with Woodfordian outwash.

Tributary floodplains. Some of the larger tributary valleys have well developed floodplains formed by the reworking and deposition of sediment by lateral migration of their streams (e.g., Plate 1, Sec. 10, T96N, R3W). The relatively flat floors of these floodplains are usually composed of different aged Holocene surfaces associated with periods of intensified lateral erosion and deposition caused by Holocene climatic changes. Holocene alluvial fills underlying the tributary floodplains are generally thin, however, the lower reaches of many of these floodplains have been alluviated in response to Holocene aggradation in the Mississippi valley. Delineation of different aged surfaces on the tributary floodplains was beyond the scope of this study.

Tributary channels. Stream channels within the tributary valleys transport sediment from their basins to the Mississippi River valley (e.g., Plate 7, Sec. 31, T93N, R2W). The flow of water in these channels is more variable than that of the Mississippi River and most of the sediment load is transported by floods that occur only a few days each year. Because of the small size of the tributary systems, the time of flooding is often out of phase with Mississippi River flooding. Therefore, much of the sediment from these tributaries is deposited locally in the main valley in the form of small alluvial fans and, consequently has only a minor, highly localized impact on the Mississippi River. The large quantity of sandy textured sediment transported by the Wisconsin River, however, has a significant impact on the morphology of the Mississippi River. This point is discussed in great detail later.

The Mississippi Valley

The Mississippi River Valley consists of terrace remnants and a modern floodplain that occupies nearly the entire valley bottom. The Mississippi floodplain includes all surface area that lies within the confines of the valley walls and below the level of the Pleistocene terraces. In the Pool No. 10 area the elevation of the floodplain typically ranges from 605 ft above sea level at Lock and Dam No. 10 to 615 ft at Lock and Dam No. 9. The Mississippi floodplain is composed of a network of channels of various sizes flowing around large elongated islands which in turn enclose numerous lakes. A significant amount of exposed land (land above pre-lock and dam low water stages) adjacent to the valley walls and terraces also exists. The surface morphology of this exposed land is similar to that of the islands suggesting a similar origin. This exposed land differs from the islands only in the fact that it has not been separated from the valley walls or terraces by a channel. Therefore, for the purpose of the geomorphic description, this distinction is not important. The individual geomorphic features found within the Mississippi Valley are described below.

Valley walls. The Upper Mississippi River is confined to a narrow, deep gorge cut into bedrock. Width of the gorge ranges from approximately one to three miles in the Pool No. 10 area. The general level of the upland surface is 400 to 500 ft above the present floodplain. Approximately 300 ft of this rise occurs abruptly as a scarp face at the edge of the general valley floor. The origin of this valley geometry has been previously described and was related to erosional episodes during the Pleistocene.

Colluvial slopes. Deposits of sediment derived directly from the slopes above flank the base of the valley walls along much of the gorge. Erosion of the valley wall slopes under the influence of gravity and running water results in basal slope accumulations of debris. This material is typically poorly sorted, ranging in grain size from clay to cobbles. The finer grain sizes are generally sandy silt derived from upland loess, whereas the angular cobbles come from the local bedrock. Throughout much of the Pool No. 10 area the main channel of the Mississippi River flows against the colluvial slopes.

Alluvial fans. Small fan-shaped deposits occur at the mouths of many tributary valleys where they enter the Mississippi River valley (e.g., Plate 5, Sec. 1, T93N, R3W). Deposition of alluvial fan sediment usually results from the abrupt decrease in valley slope at the junction of the tributary streams and the Mississippi River valley or increase in the width/depth ratio of tributary channels as they exit the uplands. Alluvial fans usually extend out onto the floodplain and valley-wall-flanking terraces a maximum distance of 1500 ft. Alluvial fan formation is also evident in the main channel of the Mississippi River in areas where the river flows directly against the colluvial slopes of the valley walls. Since flooding in the tributaries is typically out of phase with flooding in the main channel, fans are usually built out into the main channel of the Mississippi River at times of low water. During high water stages on the Mississippi River, parts of the fans may be eroded. Fan sediments are typically coarse grained (sand and gravel) in texture, are aggraded to heights of 30 ft above the Mississippi floodplain and terraces, and are well drained.

A large alluvial fan has been constructed on the floodplain of the Mississippi River at the confluence with the Wisconsin River forcing the flow of the Mississippi River against the western valley wall (Plates 3 and 5). This large alluvial fan is formed by deposition of large quantities of sand by the Wisconsin River as it enters the main valley. Because of its much lower channel slope, the Mississippi River is incapable of transporting all the sediment delivered to it by the Wisconsin River. The Wisconsin River alluvial fan is a low area subject to frequent inundation. In general, the flow of the Wisconsin River through the alluvial fan area is confined to one main channel. Several overflow channels, active at times of high water, are present on the surface of the alluvial fan.

Mississippi River terraces. Several Mississippi River terrace remnants are present in the Pool No. 10 area (e.g., Plate 6, Sec. 21, T5N, R6W).

Mississippi River terrace surfaces are generally lower in elevation than the tributary terrace surfaces ranging in elevation from 620 ft to 655 ft above sea level, or 10 ft to 45 ft above the present Mississippi River floodplain. As discussed previously, landform surfaces on these terraces are late Woodfordian to early Holocene in age and are underlain by Woodfordian sand and gravel. Prominent channel-shaped flood scour features occur on the surfaces of many of these terraces, particularly at Prairie du Chien and Bagley, Wisconsin, supporting the hypothesis of catastrophic flooding and erosion of Woodfordian alluvial fills. The original elevations of the terrace surfaces are unknown as a result of this scour. It is also unclear as to which terrace surfaces are correlated with each other and if they represent one degradational phase or a series of events. Holocene dissection of the terrace deposits and the development of drainage patterns has been limited.

Major channels. Most of the flow of the Mississippi River is directed through one or two major channels (e.g., Plate 3, Sec. 3, T95N, R3W). These channels are fairly straight and generally flow directly against the colluvial slopes of valley walls or against terraces. Major channels occupy a central position in the floodplain only where the channels are crossing from one valley side to the other. The locations of some reaches of major channels appear to have remained in nearly the same position since the time of late Woodfordian to early Holocene entrenchment (see Figure 5). In other reaches (e.g., near Harper Ferry, IA; Plate 1) the present positions of the major channels appear to be of more recent origin.

Minor channels. A large number of minor channels exist in the Mississippi floodplain (e.g., Plate 1, Sec. 35, T97N, R3W). During nonflood stages they account for only a small portion of the flow of the river. Minor channels typically follow a sinuous course and are short in length. Many minor channels appear to be truncated at their ends by the major channels. A few of the minor channels have been closed off on one end by deposition of sediment.

Abandoned channels. Abandoned channels are portions of former stream channels now separated from active flow of water. Two types of abandoned channels can be distinguished in the Pool No. 10 area. The first type is associated with the cutoff of meander bends during floods as necks of meander loops are eroded (neck cutoff) or as flood waters are diverted along prominent swales (chute cutoff). After abandonment, the channels become lakes and gradually fill with predominately fine-grained sediment. Well-defined abandoned channels of this type are not common in the Pool No. 10 area, although a few can be found west of the town of Bagley, Wisconsin (e.g., Plate 5, Sec. 7, T5N, R6W). One reason for the paucity of this type of abandoned channels may be that the major channels of the Mississippi River are constrained from meandering by the narrow width of the gorge. Another probable cause is related to the low gradient of the valley floor. In order for the sand bedload contributed from tributary streams to be transported, the major channels maintain relatively straight courses to maximize their energy gradient. The minor channels are less restricted and tend to exhibit more of a meandering planform than the major channels. However, minor channels also do not have a propensity for neck or chute cutoff. Progressive lateral migration of the sinuous minor channels, rather than abrupt changes of course, has been a more important process and swales are left behind to mark former channel positions. It is likely that the gentle valley gradient on which the channels are developed has suppressed the process of channel abandonment by neck and chute cutoff in the minor channels as well.

The second type of abandoned channel found in the Pool No. 10 area is characterized by the separation of minor channels from active flow of water (e.g., Plate 1, Sec. 11, T96N, R3W). This process is more common than abandonment by meander cutoff (neck or chute cutoff) and can be seen in varying degrees of completion. Once abandoned, the ends of the minor channels may be plugged to form long narrow lakes which may eventually fill with predominately fine-grained sediment during floods. Some of the minor channels themselves represent abandoned channels of this type in the early stages of their development. The truncating of the minor channels by the major channels suggests that some of the minor channels are no longer active and predate the present position of the major channels. However, the plugging and filling of the minor channels has not progressed extensively and, consequently, the channels remain open to the main flow of water. Only those channels that exhibited some degree of plugging and filling were mapped as abandoned channels.

Overflow channels. Overflow channels are small linear depressions on the land surface formed and used by flood flows (e.g., Plate 5, Sec. 24, T6N, R7W). These erosional features are most commonly found on the alluvial fan of the Wisconsin River and on the braided stream deposits. The dominance of sand-sized sediment in these deposits renders them susceptible to scour and modification during floods.

Lateral accretion deposits. A large portion of the exposed land of the Mississippi floodplain (islands as well as valley wall and terrace flanking floodplain land) is characterized by ridges and swales (e.g., Plate 1, Sec. 2, T96N, R3W). This undulating topography of parallel arcuate ridges approximately 5 to 10 ft in height suggests an origin by the lateral accretion of channel bars as channels migrated across the floodplain (see Figure 9 for an example lateral accretion ridge and swale topography). In meandering fluvial systems, erosion on the outside of channel bends and deposition on the inside of bends results in lateral migration of channels and construction of ridge and swale topography. The presence of the ridges and swales on the Mississippi floodplain indicates that this process has been active. The spatial distribution of ridges and swales, their configuration, and their size implies that they are generally associated with the lateral migration of the sinuous minor channels rather than the straight major channels. Lateral accretion deposits are typically composed of coarse sand to silt sized sediment. Vertical accretion of silt and clay sized sediment occurs during floods on the ridges and in the swales following their formation. This process may occur preferentially in the swales resulting in the gradual reduction of relief and production of flat floodplain surfaces. Areas of this type are mapped as a combination of vertical and lateral accretion deposits on Plates 1-7 (e.g., Plate 1, Sec. 26, T8N, R7W). However, the prominent ridge and swale pattern evident in much of Pool No. 10 indicates that vertical accretion generally occurs uniformly over the lateral accretion deposits. The subsurface topography of the sandy ridges is reflected at the surface in spite of burial by several feet of silt and clay. Areas characterized by ridge and swale topography are mapped as lateral accretion deposits regardless of the presence of a mantle of vertical accretion deposits.

It has been noted that the ridges of these deposits are frequently called "natural levees" in the literature. These deposits are not true natural levees because their topographic form results from deposition of channel bars, rather than overbank deposition. However, overbank deposition subsequent to initial formation by lateral accretion may cover the ridges with "natural levee deposits." These natural levee deposits are equivalent to the mantle of vertical accretion deposits described above.

Vertical accretion deposits. A significant portion of the Mississippi floodplain is composed of low poorly drained areas that do not appear to be underlain by ridge and swale topography (e.g., Plate 1, Sec. 2, T96N, R3W). These areas tend to be elongated parallel to the river and are surrounded on most if not all sides by ridges of lateral accretion deposits. Many of these poorly drained areas are simply wide swales, whereas others represent the intermediate area between two adjacent migrating channels. During seasonal high water discharges these areas are inundated to form lakes and they experience sedimentation of silt and clay. Vertical accretion of fine-grained sediment is the dominant geomorphic process in these poorly drained areas of the floodplain. These vertical accretion deposits are differentiated from the vertical accretion deposits that mantle the lateral accretion ridges and swales. The presence or absence of surface reflection of subsurface sandy ridges is the basis for this differentiation. Many of these areas have become permanently inundated since construction of Lock and Dam No. 10.

Vertical accretion of silt and clay has also been an important process on some erosional outliers of Woodfordian alluvium (e.g., Plate 3, Sec. 12, T7N, R7W). Postglacial entrenchment created an irregular erosional surface that passes from the Mississippi River terrace surfaces underneath the present floodplain to a depth of greater than 100 ft (see Figures 3 and 5). The subsurface topography of this fluted surface has influenced the position of the Holocene Mississippi River channels and has controlled the location of active lateral migration of channels. Vertical accretion of fine-grained sediment has occurred on this fluted surface in areas where Holocene lateral migration of channels has been precluded. Differentiation of these areas on the basis of elevation is not possible because vertical accretion has kept pace with aggradation in the active floodplain. Only those areas where silts and clays directly overlying gravels have been identified in the field have been mapped as such (all of these areas are on Plate 3). It is likely that this type of deposit is more extensive and that it can be identified by the configuration of the surface expression of the landforms it mantles. However, more subsurface exploration is necessary to determine the areal distribution of the subsurface gravel benches and their overlying fine-grained deposits.

Braided stream deposits. Downstream from the confluence with the Wisconsin River to Clayton, Iowa, there is a relative lack of ridge and swale topography indicating that progressive lateral migration of channels and lateral accretion of sediment has not been a significant process in formation of the modern floodplain. The high sediment discharge of sand from the Wisconsin River has resulted in the development of a braided channel pattern in the reach of the river immediately below the mouth of the Wisconsin River (e.g., Plate 5, Sec. 14, T94N, R3W). Braided channel patterns are characterized by an interwoven system of converging and diverging smaller channels instead of a single large meandering channel. Floodplain deposition is accomplished primarily by the growth and emergence of mid and lateral channel bars. Overflow channels, active only during flood stages, are common features on the surfaces of these deposits.

Lakes. Lakes of various shapes and sizes are abundant in the Pool No. 10 area and are most frequently found in association with lateral accretion ridge and swale topography (e.g., Plate 3, Sec. 11, T7N, R7W). Long arcuate lakes represent simply water filled swales. Larger, more elliptical lakes are located between ridges of adjacent migrating channels. These lakes, in general, are genetically related to the vertical accretion deposits described above because they occupy the same geomorphic position within the floodplain. Vertical accretion of sediment deposited from suspension is also the dominant process characterizing the lake environment, however, sediment has not filled the lakes to the level where the lake bottoms would be seasonally exposed. Permanent inundation has led to secondary erosion of many of the shorelines creating smooth lake boundaries. Erosion of the shorelines may be enhanced by wave action and the work of ice during spring thaws. Some of the lakes (e.g., Gremore Lake; Plate 3) appear to be the result of fluvial scour into the Woodfordian alluvium related to glacial lake drainage. Vertical accretion of silt and clay has occurred in these lakes throughout the Holocene. The surface areas of most lakes were expanded after closure of Lock and Dam No. 10.

Mid-channel islands. The origin of the majority of the islands in the Pool No. 10 area has already been discussed under the different types of deposits. However, many small islands exist in central positions of major channels (e.g., Plate 6, Sec. 7, T93N, R2W). These small islands tend to be elongated in the downstream direction and are more common below the confluence with the Wisconsin River. Their formation results from the shoaling of mid-channel bars and subsequent growth of a vegetative cover. Once established they become rather stable and their presence enhances further sedimentation and growth. Nonvegetated downstream extensions of the islands indicates the process of formation and the downstream direction of growth. The relatively large sediment load introduced into the Mississippi River by the Wisconsin River may explain the more frequent occurrence of mid-channel islands below its confluence. Some mid-channel islands are probably relatively young features (i.e., historic in age). However, further study may reveal that some of these islands are prehistoric landforms.

Mid and lateral channel bars. Mid and lateral channel bars are common, particularly below the Wisconsin River, however, they were not mapped because of their ephemeral nature. Channel bars are certainly important in the context of the present utilization of the river but their location through time is indeterminate and they probably have little archaeological potential.

Generalized Description of Floodplain Morphology

The Mississippi floodplain in Pool No. 10 can be divided into three distinct types of floodplain morphologies. This differentiation is based on the spatial distribution of the geomorphic features described above. North of the confluence with the Wisconsin River to Lock and Dam No. 9 and south of Clayton, Iowa, to Lock and Dam No. 10 (Plates 1, 2, 3, 6, and 7) the flow of water is subdivided into one or two major channels and many sinuous minor channels. A large portion of the exposed land (above pre-lock and dam low water stages) in these reaches of the Mississippi floodplain is composed of ridge and swale topography indicative of formation by lateral accretion of channel deposits during floods. Much of the ridge and swale topography can be associated with lateral migration of minor channels, rather than major channels. Ridges have been built along major channels but lateral migration of these channels to form extensive areas of ridge and swale topography has been limited. Numerous lakes and poorly drained depressions occur in swales and behind ridges formed by the lateral accretion of sediment by two adjacent channels. The channel slope in the reach north of the Wisconsin River, based on low water stages observed in 1930, was 2.5 in./mile (data extracted from USACE, 1929-1930). This gradient approximates the slope of the valley floor.

At the confluence with the Wisconsin River (Plates 3 and 5), the Mississippi floodplain is dominated by the Wisconsin River alluvial fan which is maintained by the high sediment discharge of the Wisconsin River. The Mississippi River is forced into one narrow and deep major channel along the western valley wall. This channel configuration is a relatively common occurrence on the Upper Mississippi River indicating that more sediment is supplied from major tributary rivers than can be carried away by the Mississippi River.

The influence of the introduction of this predominantly sand sized sediment can also be seen in the reach of the Mississippi River below the Wisconsin River to Clayton, Iowa (Plate 5). This reach can be distinguished from the reach north of the Wisconsin River by its much smaller number of meandering minor channels. Many minor channels do exist in the Mississippi valley reach below the Wisconsin fan but they tend to be straighter and more parallel to the major channels. Ridge and swale topography is less well developed and, as a consequence, lakes are not as abundant. Though nearly absent in the northern reach, mid-channel bars and islands are common in this reach downstream from the Wisconsin River. Much of the exposed land has been built up by the work of a braided channel system rather than a meandering channel system. The 1930 low water gradient in the reach south of the Wisconsin River was 3.7 in./mile, or 1.48 times the gradient of the more northerly reach (data extracted from USACE, 1929-1930). These differences can be explained by the sediment influx from the Wisconsin River. Deposition of this sediment has increased the slope of the southern segment and reduced the slope of the northern segment. Large supplies of noncohesive sand has inhibited the progressive lateral migration of channels and the construction of ridge and swale topography. The irregular growth of islands and bars has been a more important process in this reach of the Mississippi River downstream from the Wisconsin River.

Analysis of Field Data

As discussed in Part II, the Mississippi River has been experiencing aggradation since the early Holocene. In much of Pool No. 10 aggradation has occurred through the process of lateral migration of channels and the construction of ridge and swale topography. The geologic cross section displayed on Figure 10 illustrates this process. This valley cross section is located

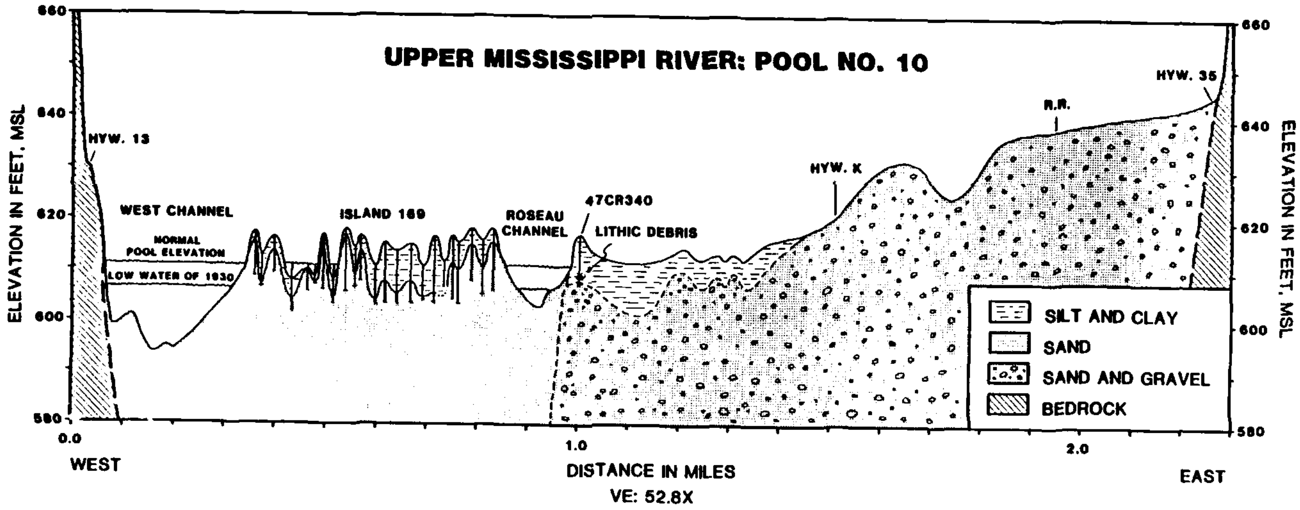


Figure 10. Geologic cross section across the Upper Mississippi valley at Island 169, Pool No. 10

two miles north of Prairie du Chien across Island 169 (Plate 3) and was constructed from a variety of sources. Twenty-three one-inch diameter soil cores were extracted with a hand soil probe from a maximum depth of 13 ft on Island 169. One core was taken from each ridge and one from each swale. Surface elevations of the core locations were determined by transit survey. A test pit was dug to a depth of 9.5 ft in the area of the archaeological site 47CR340 across Roseau Channel from Island 169. The remaining portions of the cross section were extrapolated from existing borehole data in the Pool No. 10 area and from Upper Mississippi River hydrographic surveys.

The sandy ridges beneath Island 169 displayed on Figure 10 were formed by lateral accretion of channel bars and are mantled by a deposit of silt and clay. The subsurface topography of the sandy ridges is reflected in the surface topography of the island indicating that preferential vertical accretion of silt and clay in the swales has not been significant. In general, the sandy ridge cores under the interior of the island occur at a lower elevation than those under the island margins, whereas the elevations of the surface ridge tops vary little across the island. The planform configuration of the ridges suggests that the oldest ridges occur under the island interior and they are progressively younger toward the island perimeter. These observations lead to the following interpretation. Island 169 was formed by lateral accretion of sandy ridges and subsequent vertical accretion of silt and clay. Successive ridges were deposited at higher elevations as the river system aggraded. Older ridges have a thicker mantle of silt and clay since more time has been available for deposition. This interpretation is most readily applied to the eastern two-thirds of Island 169. The depositional units form a more complex pattern under the western one-third of the island. It is possible that Island 169 is actually composed of two individual islands that merged together as they formed. The oldest portion of the island complex is located underneath the thickest mantle of silt and clay.

Seismic survey results from Island 169 (Donohue Engineers and Architects, 1983, reported in Overstreet, 1984) indicate the presence of an "interface" at a depth of 13 ft. The material overlying this "interface" was identified as loose silty soil and the underlying material was described as compacted gravel. Because this "interface" was recorded at a depth equivalent to the maximum depth cored, direct confirmation of this interpretation is not possible.

However, comparison with borehole data from Island 172 (Figure 5), a similar landform, suggests that gravelly alluvium occurs at a minimum depth of 40 ft. The material described as compacted gravel is more likely a firm sand.

In the area of 47CR340, across Roseau Channel from Island 169, additional evidence of the Holocene history of the floodplain can be found (see Figure 10 and also Overstreet, 1984). Test pit excavation revealed approximately 9 ft of silt and clay overlying gravel with an abrupt contact. At a depth of approximately 7 to 9 ft a dense concentration of cultural material (lithic debris with no diagnostic artifacts) was found in a sandy clayey silt matrix. The upper 7 ft of this section consists primarily of very fine sandy silt and clay with no prominent color or textural horizons. Stratified cultural deposits from Early Woodland to Historic in age occur in the upper 4 ft of this deposit in a nearby location (Stoltman et al., 1982). Moist colors typical of this section are very dark grayish brown (10YR 3/2 (Munsell color)) from 0 to 7 ft and dark brown (7.5YR 3/2) from 7 to 9 ft. The gravels in this section found below 9 ft are interpreted to be Woodfordian alluvium. The abrupt contact between the gravel and the overlying fine-grained material is an erosional unconformity related to late Woodfordian and early Holocene entrenchment of the Mississippi River. This erosional surface is equivalent to the surface of the terrace to the east. Following entrenchment, the Mississippi River floodplain was probably at least 40 ft below its present level (see Figure 5) and the gravels in this section were standing as a terrace. Net aggradation through the Holocene resulted in burial of this gravel bench with the vertical accretion of silt and clay from overbank flows. The initial 2 ft of burial (depth of 7 to 9 ft) apparently occurred at a rate slow enough to allow human occupation. The slight color and textural differences between this material and the overlying sediment may be the result of soil forming processes acting on this slowly accreting surface. Concurrently, the Mississippi River was aggrading its bed and floodplain. Eventually the elevation of the floodplain was such that overbank flows inundating this surface were more frequent and deposition of fine-grained sediment was more rapid. The upper 7 ft of this silt and clay was deposited as the Mississippi floodplain aggraded above the level of the gravel bench. Ground penetrating radar data (Donohue Engineers and Architects, 1983, reported in Overstreet, 1984) indicate that this gravel bench is continuous along the eastern bank of Roseau Channel and Marais Lake (Plate 3).

A broadly similar stratigraphic section to the one just described was found approximately 2.5 miles upstream on the eastern bank of Ambrough Slough (Plate 3). An exploratory hole was augered to a depth of 18.5 ft with a trailer mounted hydraulic drill rig. Approximately 12 ft of fine sandy silt and clay overlie gravels in this location. The contact with the gravels is abrupt supporting the hypothesis that it represents an erosional surface. Immediately overlying the gravels at a depth of 11 to 12 ft is a layer of reddish brown (2.5YR 4/4 to 5YR 4/4 (moist)) silty clay. This red clay is very similar to the red clay described by Flock (1983), believed to have been transported from the Lake Superior Basin during catastrophic flooding 13,100 to 9,500 years B.P. If this correlation is correct, there is little doubt that the underlying gravel is Woodfordian in age and it is separated from the red clay by an erosional surface. However, more detailed analyses are required to conclusively differentiate this red clay from the upland residual clay found in this region. The upper 11 ft of this section represents gradual accretion during the Holocene by a similar process to that described for the 47CR340 area. The gravels encountered at a depth of 12 ft probably form a bench that continues southward along the eastern bank of Ambrough Slough and Marais Lake and terminates at the inlet of Gremore Lake (Plate 3).

Holocene Floodplain Evolution

A generalized Holocene history of floodplain evolution in Pool No. 10 is described below. This scenario is based on analyses of the existing borehole data, soil data collected in the field for this project, and the spatial distribution of landforms in conjunction with the spatial and temporal distribution of diagnostic archaeological sites.

During the Holocene the Mississippi River in the Prairie du Chien area has been aggrading its floodplain because more sediment is contributed from tributary rivers than can be transported away. Aggradation of the floodplain has proceeded primarily through the process of lateral migration of channels and construction of ridge and swale topography. Successive ridges are built to higher elevations as excess sand and silt are introduced from the tributaries. Vertical accretion of silt and clay occurs on the lateral accretion deposits following their formation. As alluviation proceeded, progressively larger areas of the eroded surface on the Woodfordian gravels were buried. Burial of the gravel surfaces that are high above the level of the early Holocene floodplain was accomplished by vertical accretion of silt and clay (e.g., in the area of 47 CR 340, Figure 10). Initial burial of the gravel surfaces that occur at lower elevations (e.g., underneath Island 172; Figure 5) was accomplished by lateral accretion of sandy deposits. Sinuous minor channels appear to be primarily responsible for the lateral accretion deposits. Borehole data indicate that the major channels near Prairie du Chien have migrated little during the Holocene.

Applying absolute dates to this sequence of floodplain evolution and determination of sedimentation rates is problematic because of lack of absolute chronometric control. However, recent archaeological studies in the Mississippi floodplain near Prairie du Chien (Stoltman et al., 1982) provide clues as to the ages of some of the deposits. Middle Woodland campsites have been found buried by only 2 to 4 ft of silt and clay on lateral accretion deposits adjacent to major channels. This evidence indicates that formation of these lateral accretion deposits and the locations of the adjacent channels predates this occupation period (about 2000 to 1300 years B.P.). Campsites and shell middens (accumulations of broken clamshell debris) with Early Woodland and younger artifacts have been found buried at similar depths on ridges of lateral accretion deposits at the edges of minor channels and lakes. The implication is that the prehistoric cultures used the channels and lakes for food supply. Therefore, it is apparent that the landforms of the Mississippi floodplain in the vicinity of these sites must have been in essentially the same configuration as they are now. This interpretation implies that the landforms have changed little since about 2500 to 2000 years B.P. An alternative explanation is that the minor channels and shorelines of lakes have eroded into previously deposited sediment containing the archaeological sites and, therefore, that the present landform configuration postdates the occupation sites. However, this interpretation is inconsistent with the geomorphic and sedimentological evidence of sequential formation of the lateral accretion ridges (see Figure 10). Early Woodland and possible Late Archaic remains have been found buried approximately 2 to 4 ft within vertical accretion deposits overlying Woodfordian gravel. Therefore, initial burial of these gravel surfaces began prior to about 4000 to 2500 years B.P.

Relatively little archaeological investigation has been conducted in other areas of the Mississippi floodplain in Pool No. 10. Consequently, it is not certain if the conclusions drawn for the Prairie du Chien area are applicable to the rest of Pool No. 10. However, some inferences can be made based on the spatial pattern of landforms of the Mississippi floodplain. The floodplain morphology in the vicinity of Prairie du Chien is typical of the entire reach north of the Wisconsin River and the reach from Clayton, Iowa, to Guttenberg, Iowa. This similarity of floodplain morphology suggests a similar geomorphic history and that much of the ridge and swale topography in Pool No. 10 is older than approximately 2500 to 2000 years. The lakes and vertical accretion deposits have been undergoing sedimentation more or less continuously for at least this long.

In the area of the Wisconsin River alluvial fan and south of the Wisconsin River to Clayton, Iowa, where braided stream deposits predominate, the landforms of the floodplain are probably relatively young. In comparison to the reaches characterized by lateral accretion deposits, aggradation has been more rapid but less systematic in these areas. More reworking of former deposits has occurred with the consequent maintenance of young landforms. However, no absolute age indicators are available for these areas to allow actual dating of the landforms.

With the exception of the portion of the floodplain influenced by the influx of sediment from the Wisconsin River south of Prairie du Chien, the alluvial landforms of the Mississippi floodplain appear to have been remarkably stable for the past few thousand years. This stability can be explained in part by the gentle gradient of the valley floor inherited from late Woodfordian to early Holocene deglacial events. Stability of channel pattern in association with low valley slope has been demonstrated to occur in other multichannel river systems (Fahnestock and Bradley, 1973; Smith, 1973). Vegetation of channel banks in anastomosed river systems has also been shown to be extremely effective in producing long-term stability (Smith, 1976). This stability implies that the present landforms of the Mississippi floodplain may represent a significant portion of the Holocene. Middle to early Holocene surfaces may exist beneath vertical accretion deposits on island interiors. Examination of historic maps reveals that the major features of the floodplain have changed little in the past approximately 150 years. This evidence supports the idea of relative stability of floodplain landforms through time.

Influence of Holocene Climates

During the period of development of the present Mississippi floodplain significant changes of climate have occurred in the Upper Mississippi River basin. Climate directly influences river systems through production of runoff from precipitation and indirectly by controlling the density of vegetation on surrounding hillslopes. Climate change can alter the quantities and relative proportions of water yield and sediment yield from drainage basins and cause river channel changes. However, the response of a river system to climate change is complex and difficult to predict. The impact of Holocene climates on the geomorphic development of the Upper Mississippi River is largely unknown and needs further study. Episodes of erosion, sedimentation, and floodplain stability responding to Holocene climate changes have been documented in small drainage basins in adjacent areas (Knox, et al. 1981). Because water and sediment delivered from tributary streams affect the Mississippi River it is likely that the Holocene evolution of the floodplain was influenced by these climate changes. In addition, Knox, et al. (1975) have shown that magnitudes and frequencies of historic floods on the Upper Mississippi River have been sensitive to small-scale climatic variations. Because floods exert substantial control on the yields of water and sediment, the stability and morphology of the river system will be influenced by these same climatic variations. For these reasons a brief synopsis of Midwestern Holocene climates and their impact on small tributary streams is presented.

Climatic inferences derived from the study of pollen preserved in bog sediment in southeastern Minnesota indicate that the postglacial climate of the upper Midwest was characterized by an early Holocene warming trend and a late Holocene cooling trend (Wright, et al. 1963; Wright, 1968). The migration of the Prairie-Forest border during the Holocene in the upper Midwest and its climatic implications have been described by Bernabo and Webb (1977). Maximum warmth and dryness occurred about 7000 years B.P. and slow gradual cooling followed until about 4000 years B.P. Mean annual precipitation is estimated to have been less than 80 percent of the modern value in western Wisconsin at 6000 years B.P. (Bartlein and Webb, 1982). The shift toward cooler temperatures and more moist conditions became more pronounced after 4000 years B.P.

Paleoclimatic investigations that have studied the time distribution of radiocarbon dates representing times of environmental change have uncovered a more complex history (Bryson, et al. 1970; Wendland and Bryson, 1974). Seven distinct climatic episodes separated by abrupt and globally synchronous discontinuities have been identified. The character of these episodes has been reconstructed from the spatial distribution of pollen types during the various climatic episodes (Bryson and Wendland, 1967; Webb and Bryson, 1972). The general nature of the climates as described by Wright (1968) has been verified. However, these paleoclimate studies have demonstrated that Holocene climates have changed abruptly rather than gradually. Knox, et al. (1981) have reviewed the pollen evidence and summarized the Holocene climates of the upper Midwest as follows: cool/moist from 10,000 to 7500 years B.P., warm/dry from 7500 to 6000 years B.P., and cool/moist from 6000 years B.P. to the present.

Study of the alluvial stratigraphy in small streams in the Driftless Area of southwestern Wisconsin has shown that the streams were sensitive to Holocene climatic changes (Knox, et al. 1981). Distinct sedimentary units were associated with each of the three major subdivisions of the Holocene described above. In addition, periods of increased intensity of fluvial activity in the Driftless Area, such as periods of intensified lateral channel migration, have been shown to correspond to climatic discontinuities identified by Wendland and Bryson (1974) (Knox, 1975). It is clear that small streams in the area near Pool No. 10 responded directly to Holocene climatic fluctuations. The Mississippi River, on the other hand, integrates the effects of climate and vegetation change over a much larger drainage area. The fluvial response of the tributaries in this large drainage area to the Holocene climate changes may have been quite variable due to differences in size of tributary basins, local physiography, location in relation to climatic and vegetation boundaries (ecotones), and the intrinsic geomorphic stability of individual tributary stream systems. Therefore, the Mississippi River may have been less sensitive to these climate changes. The Mississippi River certainly must have responded to the large-scale climatic changes of the Holocene (especially the warm/dry period from 7500 to 6000 years B.P.), but it is uncertain whether each of the episodes identified by Wendland and Bryson (1974) had a significant impact on the fluvial activity of the Upper Mississippi River. Nevertheless, minor climatic shifts can be important locally as sediment is periodically flushed from tributary streams. Further study is necessary to determine the sensitivity of the Upper Mississippi River and floodplain to Holocene scale climate changes.

PART IV: ARCHAEOLOGICAL POTENTIAL OF POOL NO. 10 LANDFORMS

Introduction

Geomorphic investigations can provide valuable information which can aid in the location of prehistoric cultural resources. Maps of locations of landform features formed by specific processes can delineate areas of high and low potential of containing archaeological sites. Knowledge of the age of particular landform features can help in the location of archaeological sites of specific ages. An understanding of current and past geomorphic processes is essential in assessment of the potential for site burial or removal by erosion. Awareness of the geomorphic development of an area will permit an appropriate and effective survey strategy to be designed and utilized by the archaeologist.

Cultural Prehistory of Pool No. 10

The Pool No. 10 area has received much attention from archaeologists for over a century. Well over 300 archaeological sites have been recorded (GLARC, 1982). However, only a third of these sites are located within or adjacent to the main valley and less than 40 are actually located within the Mississippi River floodplain. The relative paucity of floodplain sites is a result of many factors. Some of the reasons for neglect of the floodplain environment by archaeologists include: (a) the assumption that the floodplain is and was inhospitable; (b) the practical limitations imposed by inundation by the locks and dams; (c) the assumption that all of the floodplain landforms are of recent (i.e., historic) origin; and (d) the fact that until the past few decades relatively few archaeologists were working in this region. The floodplain of Pool No. 10 was virtually unexplored by professional archaeologists during the twentieth century until about 1978. The archaeological investigations that have been conducted since 1978 have proven to be quite productive in terms of locating sites and artifacts (Boszhardt, 1982; Stoltman, et al. 1982; Overstreet, 1984). For the purpose of this study the Mississippi River floodplain sites were the most important and received special attention. Appendix A contains a list of the Mississippi River floodplain sites as well as other sites with identified cultural affiliations located in the Pool No. 10 area (data compiled from GLARC, 1982). The landforms in which the sites occur are also provided. A brief overview of the cultural prehistory of the Pool No. 10 area, as it is currently understood, is presented below with the purpose of identifying the general relationship between the landforms and human occupation through time. This brief account was extracted from the tentative conclusions of Stoltman, et al. (1982). For greater detail and discussion the reader should consult Boszhardt (1982), GLARC (1982), Stoltman et al. (1982), Overstreet (1984), and references cited therein.

The earliest evidence of humans in this area comes from three isolated projectile points, dated prior to 8000 years B.P., which were found on an upland surface, in an upland tributary valley and on a terrace of the Mississippi River. The provenance of these artifacts has been interpreted to indicate temporary use of the uplands and terraces by small nomadic bands of hunters and gatherers. No evidence of occupation or use of the Mississippi floodplain at that time has been found. Evidence of human presence from 8000 to 5000 years B.P. has not been found anywhere in the area. Late Archaic cultures began to populate the uplands and terraces about 5000 years B.P. Artifacts of possible Late Archaic affiliation suggest exploitation of the Mississippi floodplain resources may have began about 4000 years B.P. Early Woodland cultures in the Pool No. 10 area, dating from about 2700 to 2100 years B.P., were almost exclusively confined to the Mississippi River floodplain. Shell middens containing broken shells of fresh water clams testify to at least seasonal exploitation of the floodplain resources. A reduction in floodplain resource utilization occurred during the Middle Woodland-Trempealeau Phase about 1850-1500 B.P. Extensive floodplain resource utilization was renewed during the late Middle Woodland-Millevilie Phase about 1500-1200 B.P. From about 1100 to 800 years B.P. the Late Woodland Effigy Mound builders occupied both the terraces and the floodplain. Relatively little evidence of human occupation from 800 years B.P. to historical time has been found in Pool No. 10.

Possible Influence of Holocene Climates on Cultural Prehistory of Pool No. 10

As previously discussed, significant changes of climate occurred during the Holocene. The impact of these changes on the cultural prehistory of the Upper Mississippi Valley is largely unknown. However, there is reason to suspect that the locations of occupation sites may have been strongly influenced by the prevailing climates. Wendland and Bryson (1974) analyzed the time distribution of radiocarbon dates collected from a global sample of archaeological investigations and found that dates of discontinuity in the cultural data corresponded to their dates of climatic discontinuity. This coincidence of cultural and climatic periods suggests that changes in climatic conditions impose environmental constraints on human populations making cultural shifts more probable. Therefore, it may be instructive to review the cultural prehistory of the Pool No. 10 area in the context of Holocene climates.

Cool/moist conditions persisted from about 10,000 to 7500 years B.P. Water sources for animals and humans were abundant in upland streams as well as on the Mississippi floodplain. Early hunter and gatherer populations were small and traveled across the landscape in search of game. Because water sources were plentiful, animals, and therefore humans, may not have been drawn preferentially to the Mississippi River floodplain.

The time period from 7500 to 6000 years B.P. has been described as warm/dry. Under these climatic conditions, upland water sources may have been reduced, at least during parts of the year. The Mississippi River floodplain, and tributary floodplains as well, may have been favorable locations for animals and humans alike. The lack of evidence of human presence in Pool No. 10 during this time period may be the result of sampling biases inherent in the cultural resource survey strategies utilized. It is possible that middle Holocene surfaces and associated cultural remains exist buried beneath the island interiors in Pool No. 10. Another explanation might be that an episode of enhanced fluvial activity on the floodplain, possibly related to climatic change to cooler and more moist conditions about 6000 years B.P., removed or buried all evidence of earlier occupation. More detailed geomorphic study is necessary to establish the existence of such an episode of fluvial activity.

Cool/moist conditions again persisted from 6000 years B.P. to the present. Upland water sources would have been enhanced and animal populations may have tended to migrate away from the Mississippi River floodplain. However, the resource exploitation strategies of humans during this time period appears to have been changing. Greater reliance on food supplies derived from the river helped to maintain human populations on the terraces and the floodplain.

Archaeological Site - Landform Associations

Within the Mississippi floodplain a distinct archaeological site - landforms association can be discerned. The sites are located exclusively adjacent to bodies of water (i.e., major channels, minor channels, abandoned channels, and lakes). The archaeological materials have been recovered from in or under vertical accretion deposits that mantle lateral accretion deposits and in vertical accretion deposits overlying Woodfordian outwash gravels. These associations undoubtedly reflect a sampling bias introduced by the survey strategy employed by the investigators. Since water levels are currently high because of the lock and dam, the surveys were conducted by boat along the eroding shorelines bordering channels and lakes. In addition, most of the sites were buried by 0.5 to 2.0 meters (1.6 to 6.6 ft) of alluvium and were only visible along the eroding shorelines (Boszhardt, 1982). Recognition of this sampling bias is important so that erroneous conclusions are not drawn regarding the locational preference of archaeological sites.

Assessment of the potential of the existence of archaeological sites on or buried within the landforms of the Pool No. 10 floodplain is a difficult task due to the paucity of archaeological and chronological data. Without a complete knowledge of the purpose of the human presence on the various parts of the floodplain, the suitability of the landforms for that purpose cannot be determined. However, some generalizations related to the archaeological potential and some guidance as to the ages of the landforms and the underlying deposits can be provided.

Vertical accretion deposits that directly overlie Woodfordian gravel may contain a complete record of Holocene sedimentation. The only deposits positively identified as such are located on the eastern banks of Roseau Channel, Marais Lake, and Ambrough Slough (Plate 3). This area also contains several documented archaeological sites in the upper 2 to 4 ft of alluvium with cultural affiliations dating from as early as possibly Late Archaic (Stoltman et al., 1982). The relative lack of sand in the cores taken from the area of Roseau Channel (near 47CR340) and from adjacent to Ambrough Slough (described in Part III) indicates that vertical accretion at varying rates has been the dominant process building the deposits that overlie the gravel, and that channel migration into these areas has not occurred during the Holocene. Therefore, the lithic debris found at a depth of 7 to 9 ft near 47CR340 on Roseau Channel may be Late Archaic or older in age (see also Overstreet, 1984). It is possible that cultural material representing middle to early Holocene time may exist in the fine-grained sediment overlying this gravel bench. Coring and ground penetrating radar data indicate that the depth to gravels along this more or less continuous bench varies from approximately 9 to 12 ft.

Other buried terrace outliers may occur beneath the surface of the Pool No. 10 floodplain. Likely locations for these deposits are adjacent to present Mississippi River terraces (e.g., at Harpers Ferry and Guttenberg, Iowa, and Prairie du Chien and Bagley, Wisconsin). However, isolated buried terrace outliers may also occur. The presence of the small isolated terrace underlain by gravel in the Mississippi floodplain at the mouth of Sny Magill Creek (Plate 5) indicates that isolated buried terrace outliers may be present. The archaeological evidence demonstrates that the terrace outliers were favorable sites for human occupation and the geomorphic evidence demonstrates that conditions were favorable for site burial and preservation. Delineation of these features through more detailed subsurface exploration would be of great value to future cultural resource investigations since their archaeological potential is high.

The ages of the islands underlain by lateral accretion deposits were previously estimated (in Part III) to be older than 2500 to 2000 years B.P. on the basis of archaeological evidence. This evidence was found typically within the silty mantle capping the sandy ridges along the perimeters of islands. Because the buried interior island ridges are older than those along the perimeters, it is likely that archaeological material dating prior to 2500 years B.P. will be found under the island interiors. This material will be found either in the sandy deposits at depth or in the overlying silt and clay deposits. The implication that the underlying sandy deposits are not necessarily culturally sterile is supported by subsurface exploration along the western shore of McGregor Lake (Plate 3). A cultural shell midden of unknown age was found in a sandy matrix at a depth of 9 ft below the surface in this location (see Overstreet, 1984, for more detail). The sandy ridges under the island interiors were adjacent to bodies of water at the time of their formation. Therefore, the function of the existing sites adjacent to present bodies of water can also be postulated for sites that may exist under the island interiors. The archaeological potential of the lateral accretion deposits is considered to be high.

Because the only chronometric control available for this project was archaeological data, the ages of other landforms of the Pool No. 10 floodplain are unknown. Nevertheless, some generalizations can be made concerning their ages and archaeological potential. Many of the areas mapped as vertical accretion deposits are embedded within lateral accretion ridges. Sedimentation in these areas should represent a complete record since formation of the enclosing ridges. Vertical accretion deposits represent poorly drained conditions but the potential for the existence of evidence of specialized types of human activities (e.g., seasonal fishing or agriculture) may be high. The alluvial fan of the Wisconsin River, the braided stream deposits, and the mid-channel islands are believed to be younger than the lateral accretion deposits, however, the actual ages of these landforms are unknown. Active reworking of deposits has probably removed all but the youngest sites, if they ever existed. Their archaeological potential may be low but more field investigation is necessary to confirm this.

Site Burial and Implications for Archaeological Survey

Burial of archaeological materials by prehistoric and historic sedimentation has hampered cultural resource investigations of the Mississippi River floodplain. Boszhardt (1982) stated that archaeological sites found on the Mississippi River floodplain in Pool No. 10 are typically buried by 0.5 to 2.0 meters (1.6 to 6.6 ft) of alluvium. Some of this sediment represents floodplain deposition since European settlement of the region. Boszhardt and Overstreet (1983) reported that as much as 3 meters (9.8 ft) of historic alluvium exists in some areas of Pool No. 12, near Dubuque, Iowa. They also found that the thickness of historic alluvium was quite variable. A similar variability of thickness of historic sediment was documented in Pool No. 16, near Rock Island, Iowa (Barnhardt, et al., 1983). Burial of sites, whether by historic or prehistoric sedimentation, has required that cultural resource surveys concentrate efforts on channel and lake shorelines exposed by erosion. This strategy has proven to be effective in locating sites, but establishing site extent and continuity has been difficult. In addition, a serious bias is introduced and development of comprehensive predictive models for site locations are precluded.

Burial of sites by vertical accretion of silt and clay has been a more or less continuous process in some areas of the Pool No. 10 floodplain for at least the past 2000 to 2500 years. On many island interiors and on many Woodfordian gravel outliers this process has been occurring for a longer period of time. Rates of sedimentation may have been accelerated in historic time because of land use changes on the hillslopes of the Upper Mississippi River basin. Closure of the lock and dam has also affected sedimentation rates (GREAT I, 1980). However, field evidence suggests that accelerated sedimentation is restricted to island perimeters and other locations adjacent to active channels. Sedimentation rates have probably also increased in some minor channels, abandoned channels, and lakes in historic time (even neglecting the effect of closure of the lock and dam). Analyses of sediment cores from island interiors indicate no abrupt change in the rate of sedimentation, whereas, buried soil surfaces can be found along some island margins. Buried root crowns of living trees appear to be restricted primarily to island margins. It is believed that the thickness of historic alluvium decreases towards the island interiors as the thickness of the underlying prehistoric vertical accretion deposits increase. Total thickness of vertical accretion deposits on the islands and, therefore, potential depth of burial of prehistoric cultural material increases towards the island interiors.

In view of the findings presented in this study, it is imperative to conduct archaeological and geomorphic investigations beneath the island interiors and beneath the surface in areas where Woodfordian gravel outliers are buried by vertical accretion deposits. Deeply buried cultural material (i.e., 7 ft to at least 11 ft deep) does exist and was encountered beneath the Pool No. 10 floodplain during this study (see also Overstreet, 1984).

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The archaeological potential of landforms in the Pool No. 10 floodplain were assessed based on analysis of the geomorphic development of the floodplain in conjunction with existing archaeological data. Emphasis was placed on the landforms of the Mississippi floodplain, however, the archaeological potential of other landforms in the Pool No. 10 area is included in the following list of conclusions. The geomorphic maps (Plates 1-7) will aid in the location of archaeological sites because areas of high and low potential of containing sites are delineated. The general conclusions of the archaeological potential of Pool No. 10 landforms are as follows:

I. Tributary Valleys

a. Tributary terrace surfaces have a high potential of containing archaeological sites. These surfaces have been stable (with the exception of minor surface erosion) for nearly 10,000 years.

b. Tributary floodplains have experienced episodes of erosion, deposition, and intensified lateral channel migration during the Holocene leaving a complex mosaic of *different aged surfaces on* the tributary valley bottoms that may differ little in elevation. Some of the surfaces have been stable through much of the Holocene and have a high potential of containing archaeological sites. However, burial of tributary floodplain surfaces by accelerated sedimentation during historic time has occurred throughout many tributary valleys, resulting in burial of prehistoric cultural horizons.

II. The Mississippi Valley

a. Alluvial fans of small tributaries built into the Mississippi floodplain may have a high archaeological potential, particularly when they directly encroach upon the major channels of the Mississippi River. These areas may represent the only habitable land along those portions of the valley walls abutting the main channel and are also located along access routes to the uplands. The potential for site burial on alluvial fans is high due to the predominance of depositional over erosional processes.

b. Mississippi River terrace surfaces have a high potential of containing archaeological sites. These surfaces have been stable for nearly

10,000 years. The higher elevations on these surfaces have probably not been inundated by floodwaters for this length of time and therefore alluvial deposition and subsequent site burial has not occurred.

c. Mississippi River terrace outliers buried by vertical accretion deposits have a high archaeological potential. A significant portion of the Holocene record may be preserved in the fine-grained sediment capping these outliers.

d. Islands underlain by lateral accretion deposits have a high potential of containing archaeological sites. Prehistoric cultural material will be found in or beneath the vertical accretion deposits that mantle the lateral accretion deposits. Buried sandy ridges under the island interiors are older than those along the island perimeters and some may represent middle to possibly early Holocene landforms.

e. Areas mapped as vertical accretion deposits may have a high potential of containing evidence of specialized types of human activities (e.g., seasonal fishing or agriculture). Poorly drained conditions may have precluded more intensive use of these areas. A significant portion of the Holocene record may be preserved in some of these deposits.

f. The archaeological potential of the alluvial fan of the Wisconsin River, the braided stream deposits, and the mid-channel islands is uncertain. Active reworking of deposits would have removed all but the youngest sites, however, the actual ages of these landforms and the rates of reworking by natural processes are unknown. The potential of finding late Prehistoric cultural features may be high in areas which have not been recently reworked.

Recommendations

Many of the limitations of this present study, as outlined in Part I, can be removed or diminished by conducting additional field investigation in the Pool No. 10 area and in other pools of the Upper Mississippi River. While the findings of this report can serve as a basis from which to design cultural resource survey strategies, many questions related to the geomorphic history of Pool No. 10 and the Upper Mississippi River remain unresolved. A more detailed chronology of the geomorphic history of the Upper Mississippi River will be valuable for future archaeological investigations and will also provide important information about the physical conditions that control the natural hydraulic stability of the river and floodplain system. Some of the unresolved questions that have important implications for archaeological investigation and channel maintenance and floodplain management activities are:

a. What was the impact of Holocene climates and Holocene episodes of intensified fluvial activity in tributary streams on the Mississippi River?

b. Are early and middle Holocene surfaces preserved beneath the floodplain or were they removed by erosion?

c. What is the areal distribution and thickness of post-European settlement alluvium on the landforms of the Mississippi River floodplain?

d. Are the conclusions drawn for the Pool No. 10 area applicable to a much larger reach of the Upper Mississippi River?

More intensive geomorphic study can help to answer these questions. Future geomorphic investigations should be concentrated on the floodplain and terraces of the various pools of the Upper Mississippi River, however, they should not be restricted to these areas. The well-known alluvial chronologies of the tributaries need to be extended where possible into the Mississippi River floodplain. Answers to many of the questions related to the geomorphic history of the Mississippi floodplain will be found in the tributaries. Specific activities that should be pursued include:

a. Construction and field verification of geomorphic maps of the areas within and adjacent to the navigation pools (as has been completed for Pool No. 10).

b. Analysis of existing data (borehole data, topographic maps, geologic maps, etc.) to determine valley fill stratigraphy, depth to bedrock, and longitudinal profiles of bedrock floor, floodplain, channels, and terrace surfaces.

c. Subsurface exploration on the various landforms of the floodplain and on the terraces using portable coring devices.

d. Laboratory analyses of cores to determine grain size distribution, mineralogy and other physical and chemical properties with depth.

e. Examination of the degree of pedogenic development on the various landforms of the floodplain and on the terraces.

f. Radiocarbon dating of organic materials extracted from beneath the floodplain where found in appropriate depositional contexts.

Pursuit of these activities will ultimately provide a comprehensive model for the geomorphic evolution of the Upper Mississippi River. This model will have great utility for a comprehensive cultural resource survey and will also provide valuable information to engineers and planners concerned with the natural behavior of the Upper Mississippi River and floodplain system and its response to artificial modifications.

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APPENDIX A: POOL NO. 10 ARCHAEOLOGICAL SITES WITH IDENTIFIED CULTURAL AFFILIATIONS

SOURCE: Primarily GLARC (1982); also Stoltman, et al. (1982) and Boszhardt (1982)

Site Number	Landform*	Location	Cultural Affiliation
Sites in Iowa			
AM-77	MT	Sec. 24 T97N R3W	Woodland/Effigy Mounds
AM-78	MT	Sec. 7 T97N R2W	Woodland
AM-80	MT	Sec. 23 T97N R3W	Woodland
AM-81	MT	Sec. 26 T97N R3W	Woodland
AM-107	TT	Sec. 33 T96N R3W	Late Woodland
AM-109	MT	Sec. 26 T97N R3W	Effigy
AM-116	AF	Sec. 34 T97N R3W	Woodland
AM-117	MT	Sec. 24 T97N R3W	Woodland (Early and Late) (Red Ochre)
AM-148	MT	Sec. 26 T97N R3W	Woodland
AM-150	MT	Sec. 7 T97N R2W	Woodland/Hopewell - Middle Woodland
AM-151	MT	Sec. 24 T97N R3W	Late Woodland, Milleville and Keyes Phase
AM-152	MT	Sec. 24 T97N R3W	Woodland
AM-153	MT	Sec. 7 T97N R2W	Woodland
AM-154	MT	Sec. 7 T97N R2W	Woodland
AM-155	MT	Sec. 24 T97N R3W	Woodland
AM-156	AF	Sec. 26 T97N R3W	Woodland
AM-158	MT	Sec. 18 T97N R2W	Woodland, Prairie?
AM-161	MT	Sec. 13 T97N R3W	Woodland
AM-210	TT	Sec. 34 T96N R3W	Middle Woodland (Havana Hopewell) Late Woodland and Oneota
AM-228	AF	Sec. 27 T96N R3W	Some Prairie Phase and Middle and Late Woodland and Historic
AM-235	MT	Sec. 26 T97N R3W	Archaic-Late Woodland
AM-236	MT	Sec. 23 T97N R3W	Woodland
AM-237	MT	Sec. 13 T97N R3W	Woodland
AM-245	MT	Sec. 23 T97N R3W	Probably Woodland
AM-247	TT	Sec. 23 T97N R3W	Probably Woodland

* See page A5 for explanation of landform symbols.

Site Number	Landform	Location	Cultural Affiliation
AM-249	MT	Sec. 23 T97N R3W	Woodland
AM-251	MT	Sec. 24 T97N R3W	Probably Woodland
AM-254	TT	Sec. 7 T97N R2W	Woodland
AM-255	TF	Sec. 7 T97N R2W	Late Woodland
AM-258	MT	Sec. 7 T97N R2W	Historic
CT-18	MT	Sec. 23 T94N R3W	Milleville-Keyes Transition Phase
CT-31	MT	Sec. 20 T93N R2W	Early to Late Middle Woodland (to Late Middle Hopewell)
CT-32	MT	Sec. 20 T93N R2W	Middle Woodland
CT-34	TT	Sec. 32 T93N R2W	Woodland
CT-45	MT	Sec. 32 T93N R2W	Keyes Phase-Late Woodland
CT-47	TT	Sec. 31 T93N R2W	Archaic, Early and Late Woodland
CT-66	MT	Sec. 5 T92N R2W	Woodland, Historic Indian
Sites in Wisconsin			
CR-3	MT	Sec. 7 T6N R6W	Middle Woodland/Late Woodland
CR-7	MT	Sec. 24 T7N R7W	Middle Woodland?
CR-8	MT	Sec. 7 T6N R6W	Middle Woodland/Late Woodland
CR-14	TT	Sec. 8 T6N R6W	Woodland
CR-32	TT	Sec. 18 T8N R6W	Middle Woodland-Hopewell
CR-35	TT	Sec. 25 T8N R7W	Late Woodland-Effigy Mounds
CR-50	VA/MT	Sec. 12 T7N R7W	Middle Woodland/Hopewell
CR-53	MT	Sec. 24 T7N R7W	Late Woodland-Effigy Mound
CR-54	MT	Sec. 24 T7N R7W	Woodland
CR-59	TT	Sec. 18 T7N R6W	Late Woodland-Effigy Mounds
CR-61	TT	Sec. 5 T6N R6W	Late Woodland-Effigy Mounds
CR-62	MT	Sec. 26 T7N R7W	Hopewell
CR-78	TF	Sec. 18 T7N R6W	Late Woodland-Effigy Mounds
CR-82	MT	Sec. 8 T6N R6W	Middle Woodland
CR-83	MT	Sec. 8 T6N R6W	Late Woodland
CR-88	MT	Sec. 8 T6N R6W	Middle Woodland/Late Woodland
CR-92	MT	Sec. 1 T6N R7W	Middle Woodland?
CR-100	TF	Sec. 6 T7N R6W	Middle Woodland

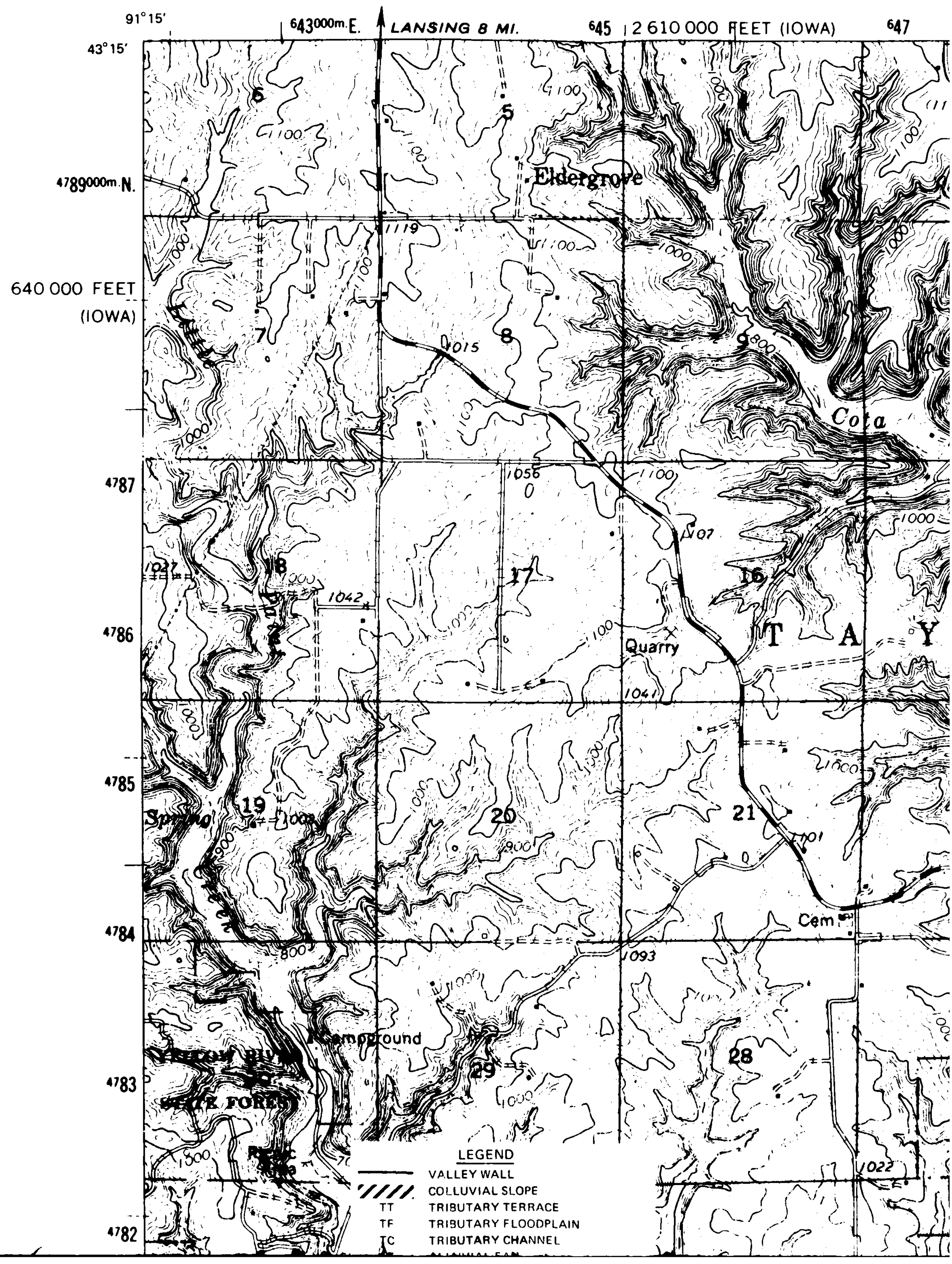
Site Number	Landform	Location	Cultural Affiliation
CR-103	VA/MT	Sec. 23 T7N R7W	Archaic/Early Woodland/Middle Woodland
CR-127	MT	Sec. 1 T7N R7W	Middle Woodland-Hopewell, Late Woodland-Effigy Mounds
CR-131	MT	Sec. 24 T7N R7W	Archaic/Middle Woodland/Historic Indian
CR-142	AF	Sec. 5 T8N R6W	Historic Indian
CR-146	LA	Sec. 25 T8N R7W	Woodland
CR-148	TF	Sec. 29 T8N R6W	Late Woodland-Effigy Mound
CR-154	TT	Sec. 6 T7N R6W	Woodland
CR-155	TT	Sec. 18 T7N R6W	Woodland
CR-156	TT	Sec. 18 T7N R6W	Late Woodland
CR-157	TF	Sec. 18 T7N R6W	Late Woodland
CR-158	AF	Sec. 18 T7N R6W	Late Woodland-Effigy Mounds
CR-161	TT	Sec. 8 T6N R6W	Late Woodland-Effigy Mounds
CR-166	MT	Sec. 31 T7N R6W	Historic
CR-167	MT	Sec. 25 T7N R7W	Prehistoric/Euro-American
CR-185	VA/MT	Sec. 23 T7N R7W	Archaic, Middle Woodland/Late Woodland
CR-186	VA/MT	Sec. 13 T7N R7W	Late Archaic through Late Woodland
CR-187	VA/MT	Sec. 13 T7N R7W	Multi-Component, Archaic through Late Woodland
CR-189	VA/MT	Sec. 13 T7N R7W	Mainly Late Woodland
CR-190	MT	Sec. 8 T6N R6W	Woodland and Historic
CR-191	MT	Sec. 8 T6N R6W	Woodland and Historic
CR-192	MT	Sec. 6 T6N R6W	Early Woodland-Historic
CR-193	MT	Sec. 6 T6N R6W	Early Woodland-Historic
CR-201	TF	Sec. 6 T7N R6W	Historic
CR-206	TF	Sec. 5 T7N R6W	Woodland
CR-208	TF	Sec. 5 T7N R6W	Woodland
CR-210	TT	Sec. 6 T7N R6W	Woodland
CR-245	MT	Sec. 24 T7N R7W	Archaic/Old Copper
CR-247	MT	Sec. 36 T7N R7W	Euro-American, Military
CR-248	MT	Sec. 24 T7N R7W	Archaic/Middle Woodland/Historic Indian

Site Number	Landform	Location	Cultural Affiliation
CR-249	MT	Sec. 25 T7N R7W	Historic
CR-252	MT	Sec. 36 T7N R7W	Menominee
CR-253	MT	Sec. 1 T6N R7W	Euro-American, Military
CR-254	MT	Sec. 25 T7N R7W	Euro-American, Military
CR-255	MT	Sec. 25 T7N R7W	Euro-American
CR-256	MT	Sec. 25 T7N R7W	Euro-American
CR-308	LA	Sec. 1 T7N R7W	Late Woodland-Effigy Mound
CR-309	LA	Sec. 1 T7N R7W	Early/Middle/Late Woodland and Late Prehistoric
CR-311	LA	Sec. 1 T6N R7W	Middle Woodland
CR-312	LA	Sec. 12 T6N R7W	Middle and Late Woodland
CR-313	LA	Sec. 12 T6N R7W	Middle and Late Woodland
CR-314	LA	Sec. 12 T6N R7W	Woodland/Historic
CR-339	MT	Sec. 6 T6N R6W	Late Archaic/Early Woodland/Historic
CR-340	VA/MT	Sec. 23 T7N R7W	Late Woodland/Historic
CR-341	LA	Sec. 2 T7N R7W	Middle Woodland/Historic
CR-348	VA/MT	Sec. 23 T7N R7W	Woodland/Historic
CR-349	LA	Sec. 1 T7N R7W	Late Paleo (?) Late Woodland, Historic
CR-350	LA	Sec. 1 T7N R7W	Late Woodland/Earlier (?)
CR-352	VA/MT	Sec. 13 T7N R7W	Middle-Late Woodland
CR-353	VA/MT	Sec. 12 T7N R7W	Late Woodland
CR-354	LA	Sec. 35 T7N R7W	Late Archaic/Middle Woodland
CR-356	LA	Sec. 14 T7N R7W	Middle-Late Woodland
CR-357	LA	Sec. 14 T7N R7W	Late Woodland
CR-358	LA	Sec. 14 T7N R7W	Woodland/Historic
CR-359	LA	Sec. 11 T7N R7W	Late Woodland/Historic
CR-360	LA	Sec. 12 T6N R7W	Late Woodland
CR-364	LA	Sec. 1 T6N R7W	Early to Middle Woodland
CR-366	LA	Sec. 2 T6N R7W	Middle Mississippian
CR-367	LA	Sec. 2 T6N R7W	Middle to Late Woodland
CR-368	LA	Sec. 11 T6N R7W	Middle Woodland?
CR-369	LA	Sec. 2 T6N R7W	Transitional Middle-Late Woodland
CR-370	VA/MT	Sec. 13 T7N R7W	Early Woodland/Late Woodland (?)

Site Number	Landform	Location	Cultural Affiliation
CR-371	LA	Sec. 36 T7N R7W	Early Woodland
GT-14	MT	Sec. 21 T5N R6W	Late Woodland-Effigy Mound
GT-16	MT	Sec. 27 T5N R6W	Woodland
GT-17	MT	Sec. 27 T5N R6W	Woodland
GT-18	MT	Sec. 27 T5N R6W	Woodland
GT-19	MT	Sec. 27 T5N R6W	Woodland
GT-20	MT	Sec. 27 T5N R6W	Hopewell
GT-126	MT	Sec. 17 T5N R6W	Woodland
GT-127	MT	Sec. 17 T5N R6W	Woodland
GT-131	MT	Sec. 17 T5N R6W	Woodland
GT-134	LA	Sec. 18 T5N R6W	Woodland

Explanation of Landform Symbols (See Part III and Plates 1-7)

TT - Tributary Terrace
TF - Tributary Floodplain
AF - Alluvial Fan
MT - Mississippi River Terrace
LA - Lateral Accretion Deposit
VA/MT - Vertical Accretion Deposit Over Mississippi River Terrace



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4782
Eldergrove
Cota
Quarry
T A Y
Spring
Creek
Campground
STATE FOREST
Cem.
LEGEND
VALLEY WALL
COLLUVIAL SLOPE
TT TRIBUTARY TERRACE
TF TRIBUTARY FLOODPLAIN
TC TRIBUTARY CHANNEL

T (IOWA)
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648
10′
649
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651
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43°15′
T A Y L O R
Cota
Creek
Spring Branch Creek
Creek
Harpers Ferry
CHICAGO
MILWAUKEE
ST PAUL
Slough
River Island
RIVER
Cem
Cem.
Mile
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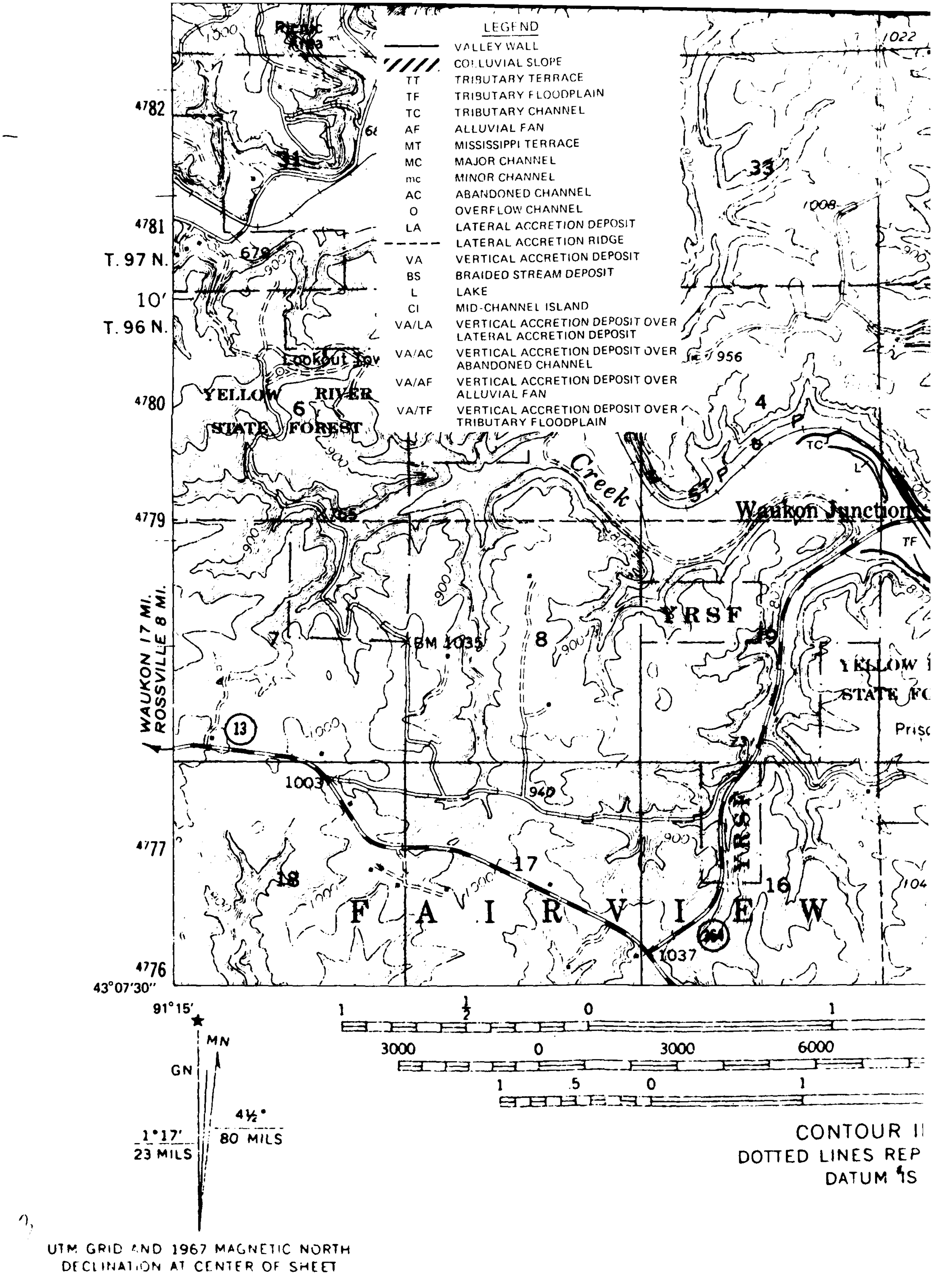

LEGEND
VALLEY WALL
COLLUVIAL SLOPE
TT TRIBUTARY TERRACE
TF TRIBUTARY FLOODPLAIN
TC TRIBUTARY CHANNEL
AF ALLUVIAL FAN
MT MISSISSIPPI TERRACE
MC MAJOR CHANNEL
mc MINOR CHANNEL
AC ABANDONED CHANNEL
O OVERFLOW CHANNEL
LA LATERAL ACCRETION DEPOSIT
LATERAL ACCRETION RIDGE
VA VERTICAL ACCRETION DEPOSIT
BS BRAIDED STREAM DEPOSIT
L LAKE
CI MID-CHANNEL ISLAND
VA/LA VERTICAL ACCRETION DEPOSIT OVER LATERAL ACCRETION DEPOSIT
VA/AC VERTICAL ACCRETION DEPOSIT OVER ABANDONED CHANNEL
VA/AF VERTICAL ACCRETION DEPOSIT OVER ALLUVIAL FAN
VA/TF VERTICAL ACCRETION DEPOSIT OVER TRIBUTARY FLOODPLAIN
4782
4781
T. 97 N.
10′
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YELLOW RIVER STATE FOREST
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940
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1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 20 FEET

TED LINES REPRESENT 5-FOOT CONTOURS

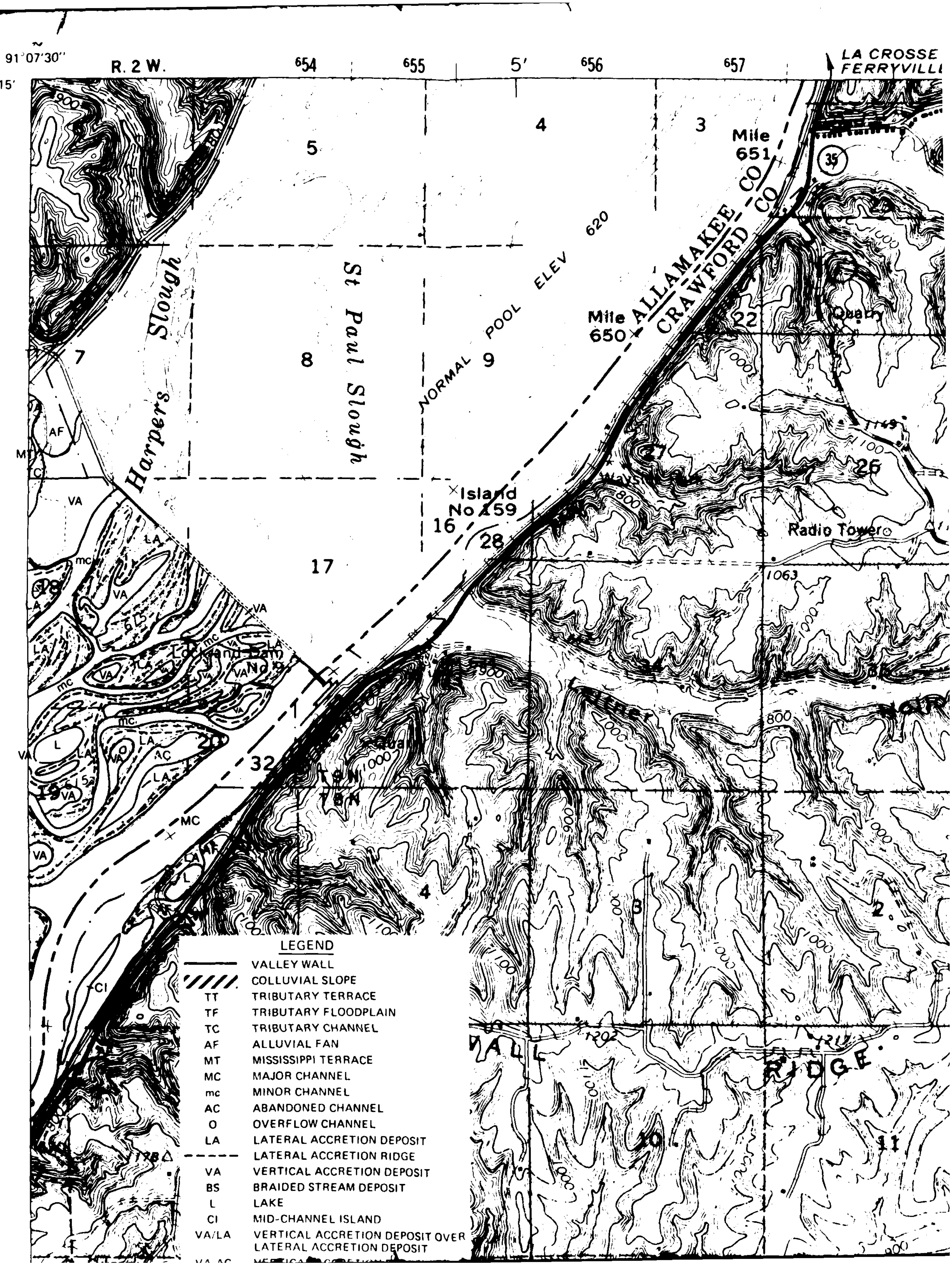
DATUM IS MEAN SEA LEVEL

GEOMORPHOLOGY OF POOL 10

PRAIRIE DU CHIEN NW

PLATE 1

41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LA CROSSE
FERRYVILLE
Mile 651
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ALLAMAKEE CO
CRAWFORD CO
NORMAL POOL ELEV 620
Harpers Slough
St Paul Slough
Island No 159
Lock and Dam No 9
Radio Tower
Quarry
Ways
1063
1149
1202
1217
T 9 N
T 8 N
RIDGE
LEGEND
VALLEY WALL
COLLUVIAL SLOPE
TT TRIBUTARY TERRACE
TF TRIBUTARY FLOODPLAIN
TC TRIBUTARY CHANNEL
AF ALLUVIAL FAN
MT MISSISSIPPI TERRACE
MC MAJOR CHANNEL
mc MINOR CHANNEL
AC ABANDONED CHANNEL
O OVERFLOW CHANNEL
LA LATERAL ACCRETION DEPOSIT
LATERAL ACCRETION RIDGE
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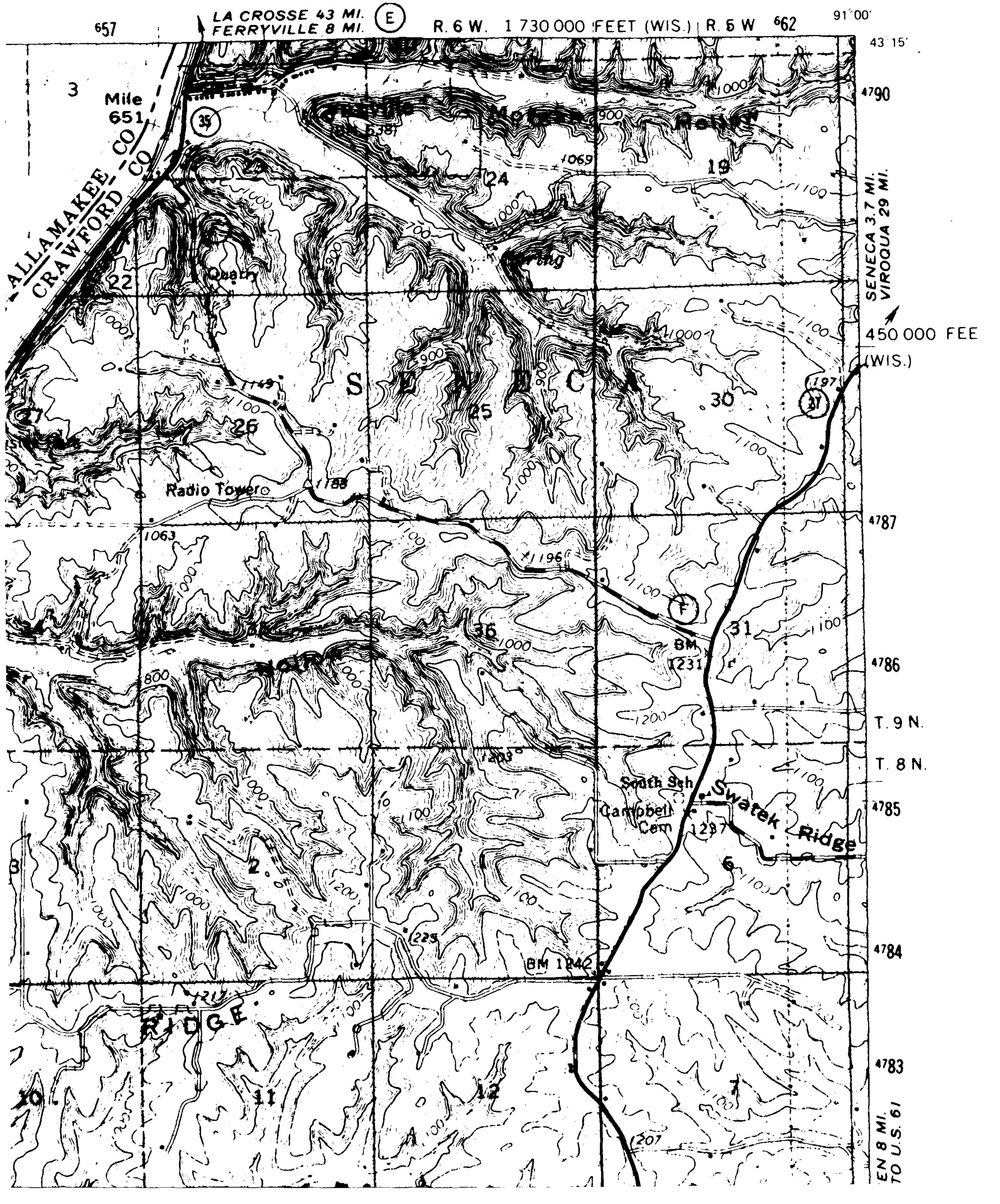

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4790
4787
4786
4785
4784
4783
450 000 FEET (WIS.)
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T. 8 N.
SENECA 3.7 MI.
VIROQUA 29 MI.
TO U.S. 61
ALLAMAKEE CO
CRAWFORD CO
Mile 651
35
27
Quarry
Radio Tower
SENECA
Spring
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2
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1069
1149
1188
1063
1196
BM 1231
1203
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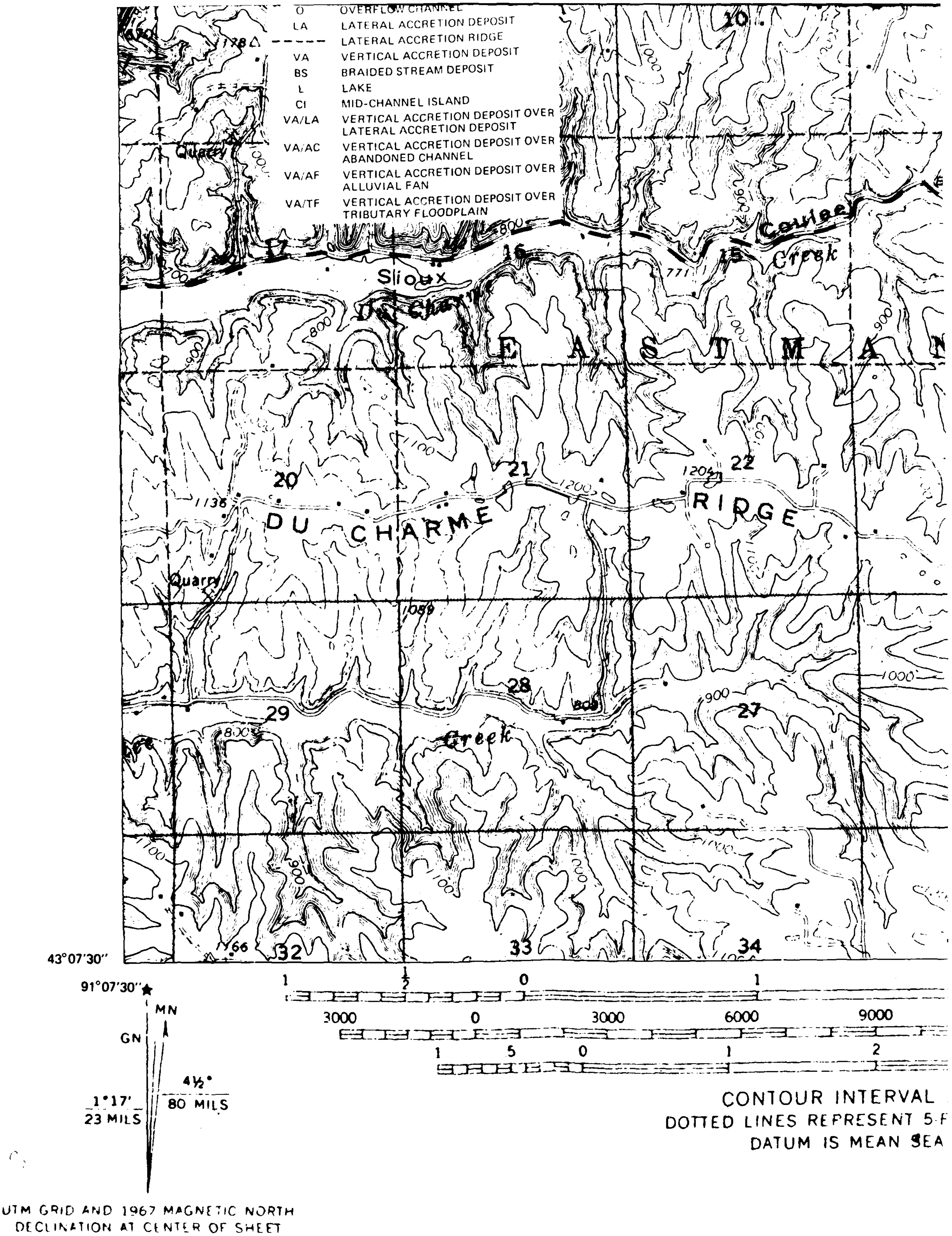

O OVERFLOW CHANNEL
LA LATERAL ACCRETION DEPOSIT
LATERAL ACCRETION RIDGE
VA VERTICAL ACCRETION DEPOSIT
BS BRAIDED STREAM DEPOSIT
L LAKE
CI MID-CHANNEL ISLAND
VA/LA VERTICAL ACCRETION DEPOSIT OVER LATERAL ACCRETION DEPOSIT
VA/AC VERTICAL ACCRETION DEPOSIT OVER ABANDONED CHANNEL
VA/AF VERTICAL ACCRETION DEPOSIT OVER ALLUVIAL FAN
VA/TF VERTICAL ACCRETION DEPOSIT OVER TRIBUTARY FLOODPLAIN
Quarry
Sioux
Coulee
Creek
EASTMAN
DU CHARME RIDGE
Quarry
Creek
43°07'30"
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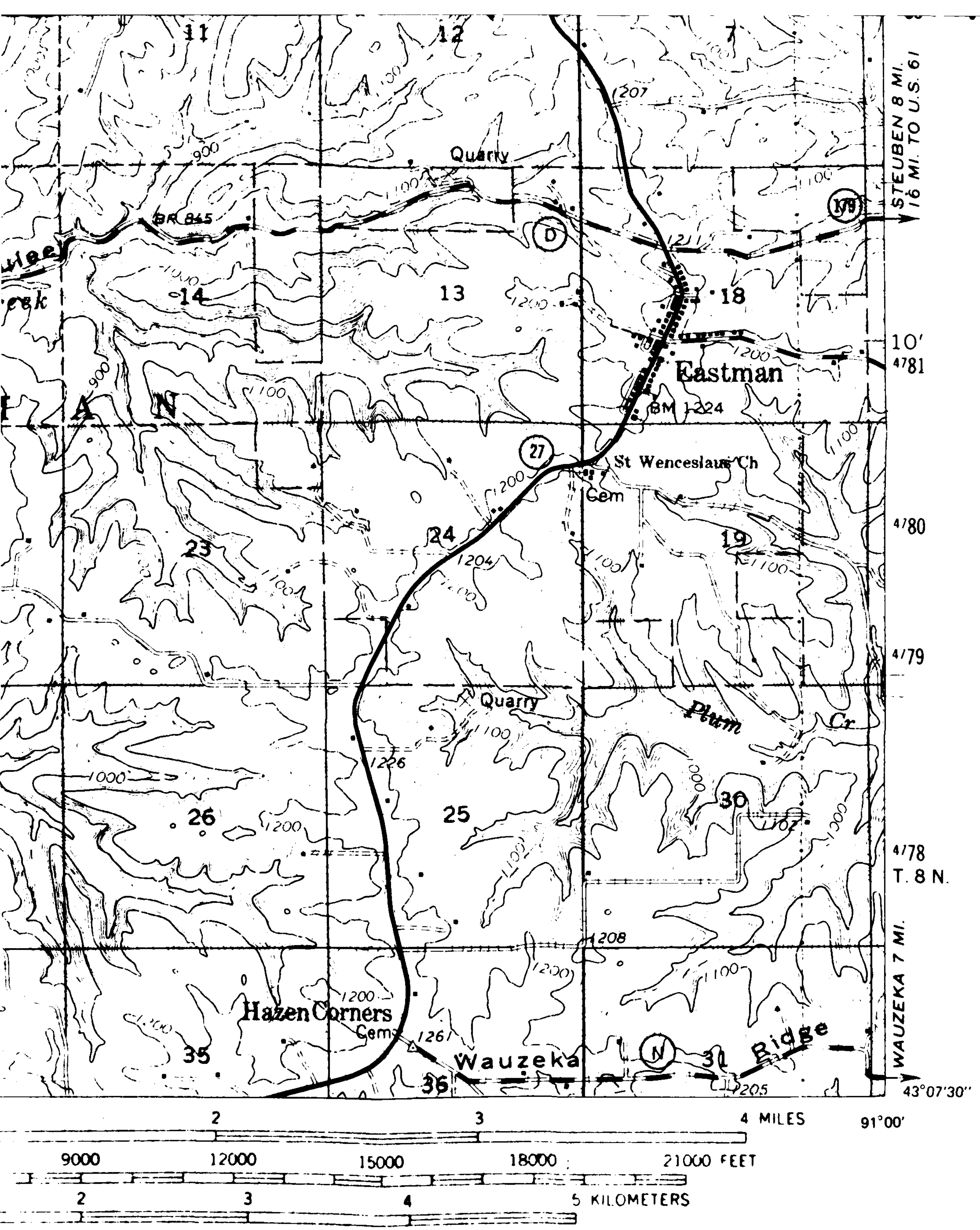
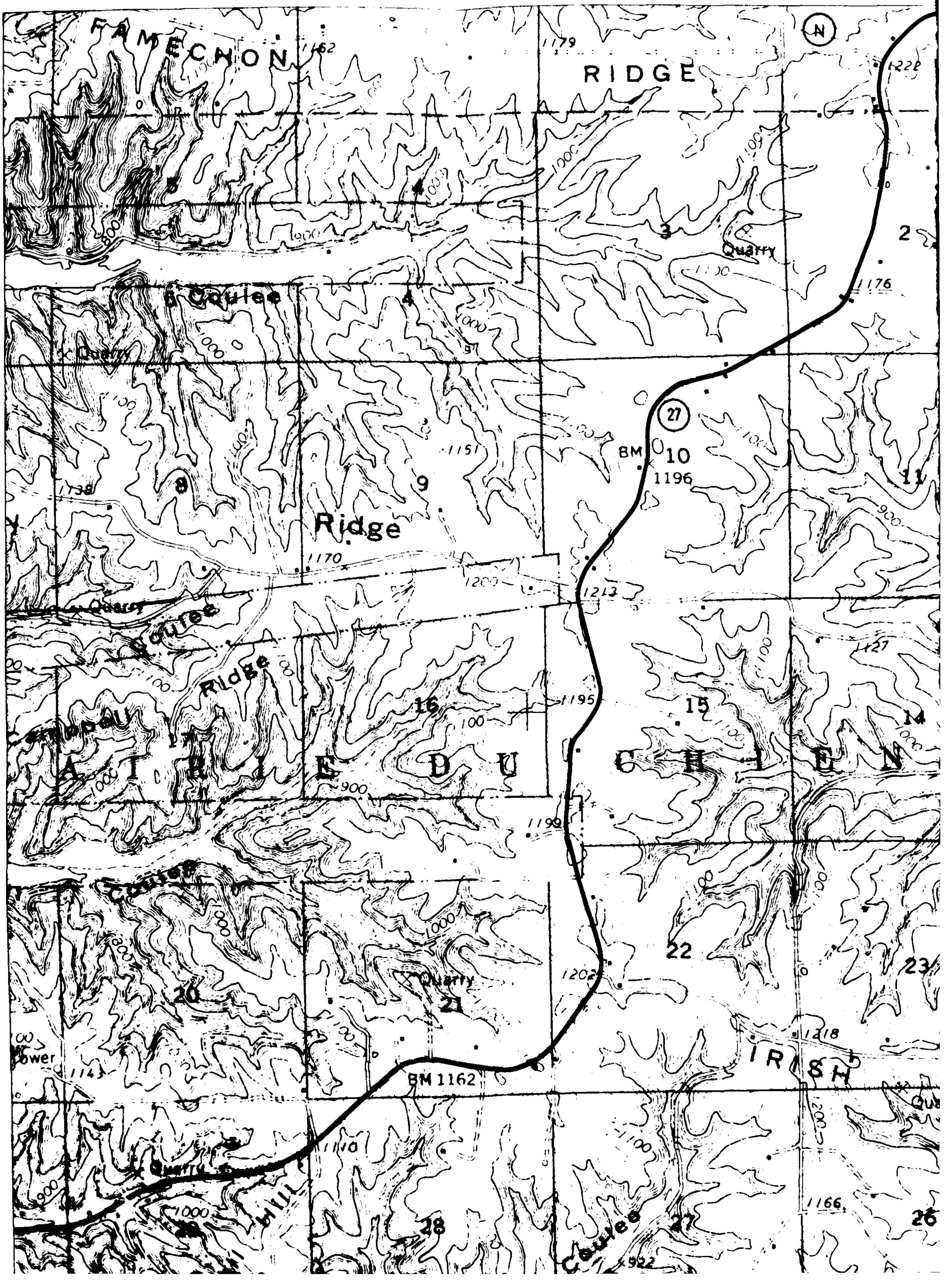
UTM GRID AND 1967 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET
CONTOUR INTERVAL
DOTTED LINES REPRESENT 5 F
DATUM IS MEAN SEA

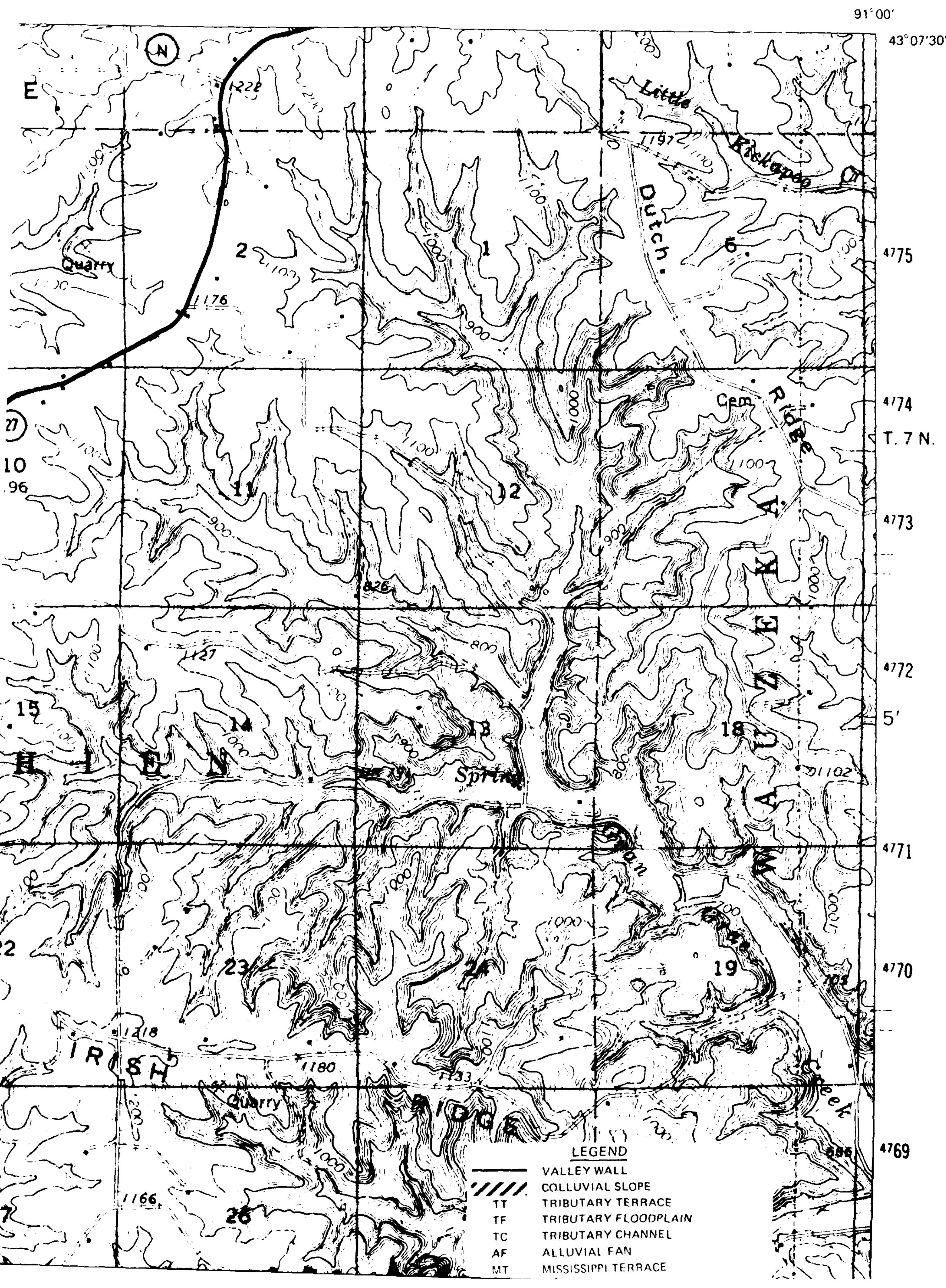


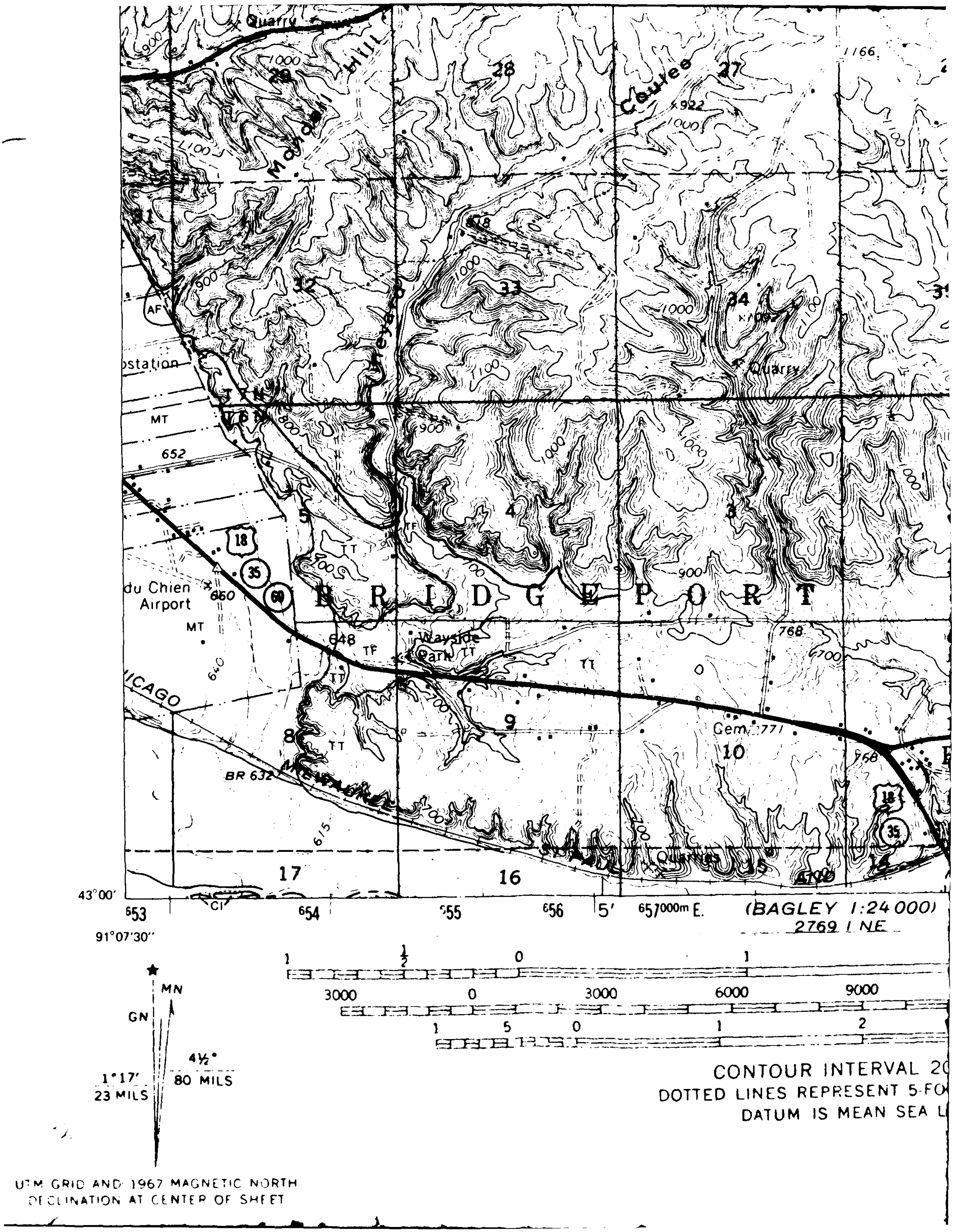
IR INTERVAL 20 FEET
REPRESENT 5-FOOT CONTOURS
M IS MEAN SEA LEVEL

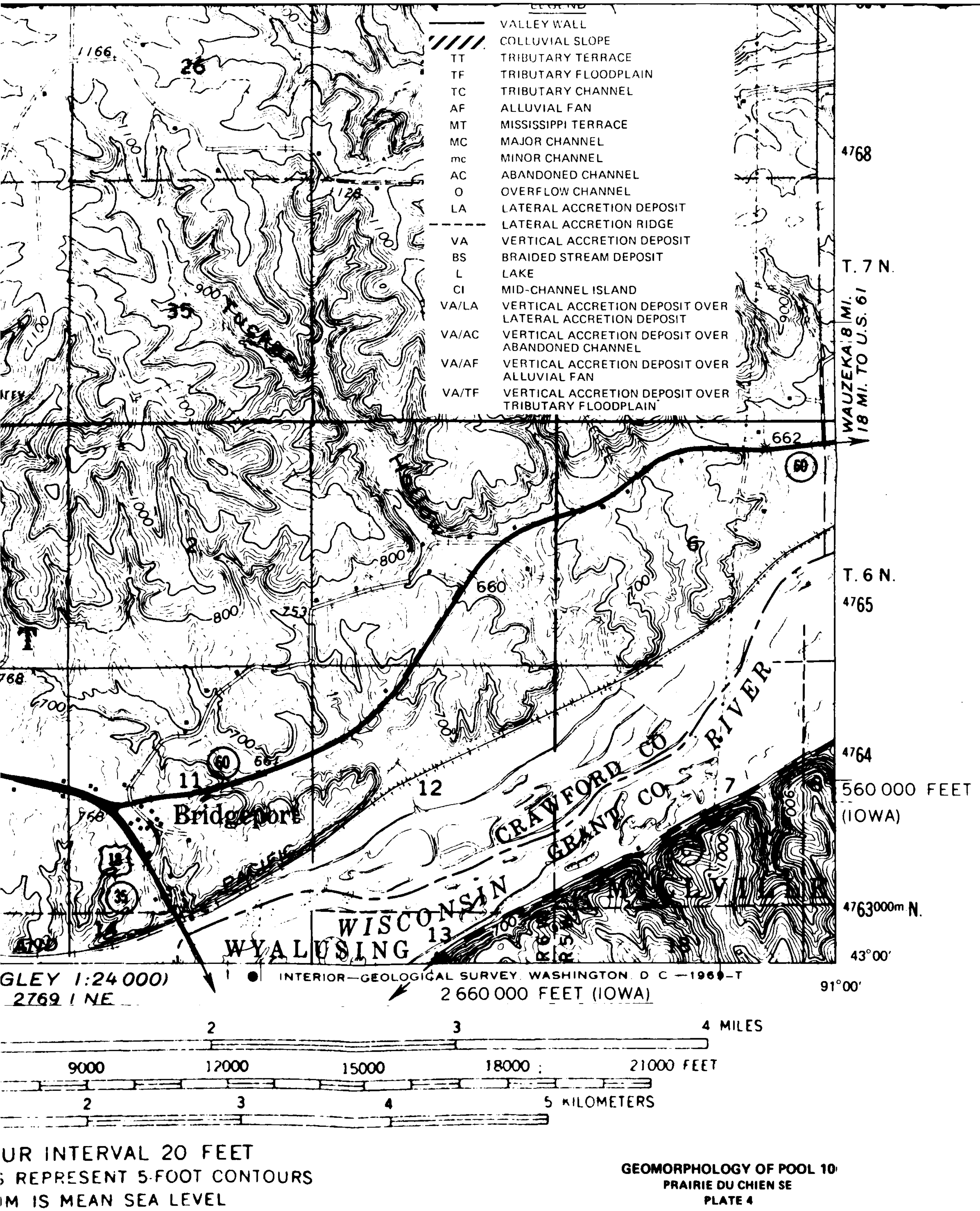
GEOMORPHOLOGY OF POOL 10
PRAIRIE DU CHIEN NE
PLATE 2

91°07'30"
43°07'30"

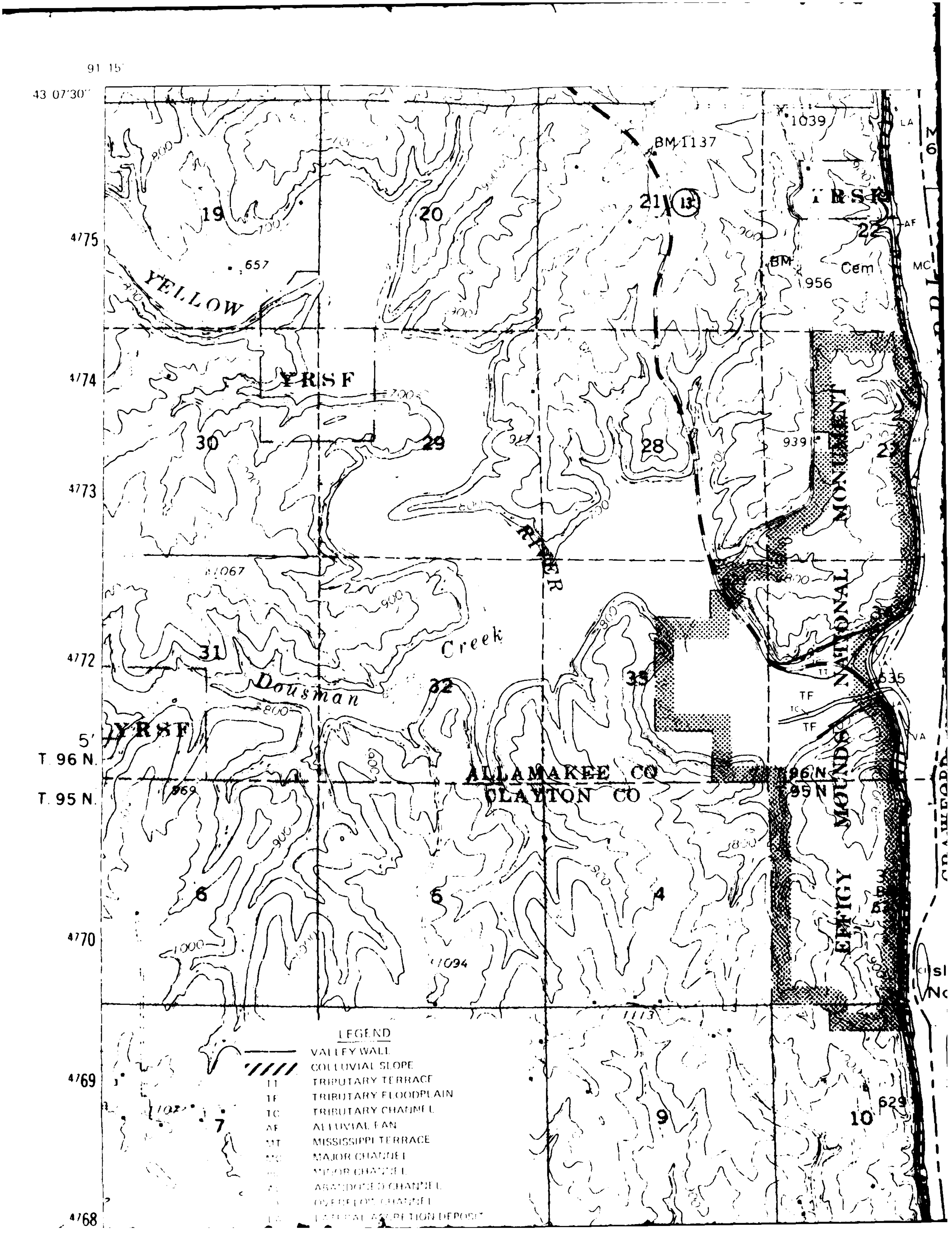



91°00′
43°07′30″
Little Kickapoo Cr
Dutch Ridge
Quarry
Cem
Spring
Creek
IRISH RIDGE
HIENEN
KAZEAM
4775
4774
T. 7 N.
4773
4772
5′
4771
4770
4769
1
2
6
7
10
11
12
13
14
15
18
19
22
23
24
26
1222
1176
1197
1127
1102
1218
1180
1166
826
LEGEND
VALLEY WALL
COLLUVIAL SLOPE
TT TRIBUTARY TERRACE
TF TRIBUTARY FLOODPLAIN
TC TRIBUTARY CHANNEL
AF ALLUVIAL FAN
MT MISSISSIPPI TERRACE

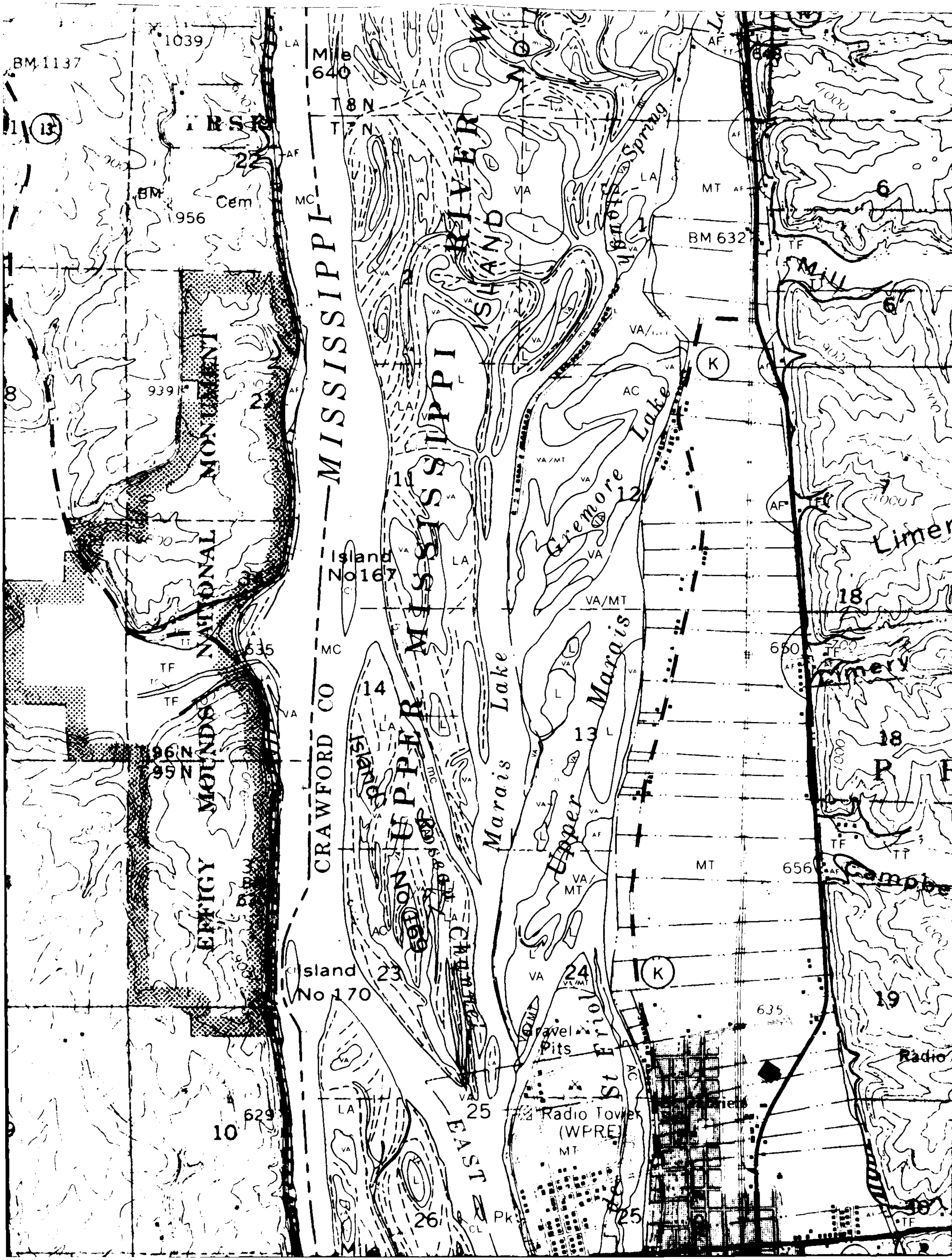

Quarry
Mohawk Hill
Coulee
28
27
29
1166
922
1000
900
1100
33
32
34
31
AF
station
Quarry
T 7 N
T 6 N
MT
652
800
900
4
5
3
18
35
60
du Chien
Airport
650
B R I D G E P O R T
768
700
648
TF
TT
Wayside
Park
640
CHICAGO
Cem 771
9
10
8
BR 632
615
17
16
14
Quarries
43°00′
653
654
655
656
657000m E.
(BAGLEY 1:24 000)
2769 I NE
91°07′30″
MN
GN
4½°
80 MILS
1°17′
23 MILS
3000
6000
9000
CONTOUR INTERVAL 2
DOTTED LINES REPRESENT 5-FO
DATUM IS MEAN SEA L
UTM GRID AND 1967 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET



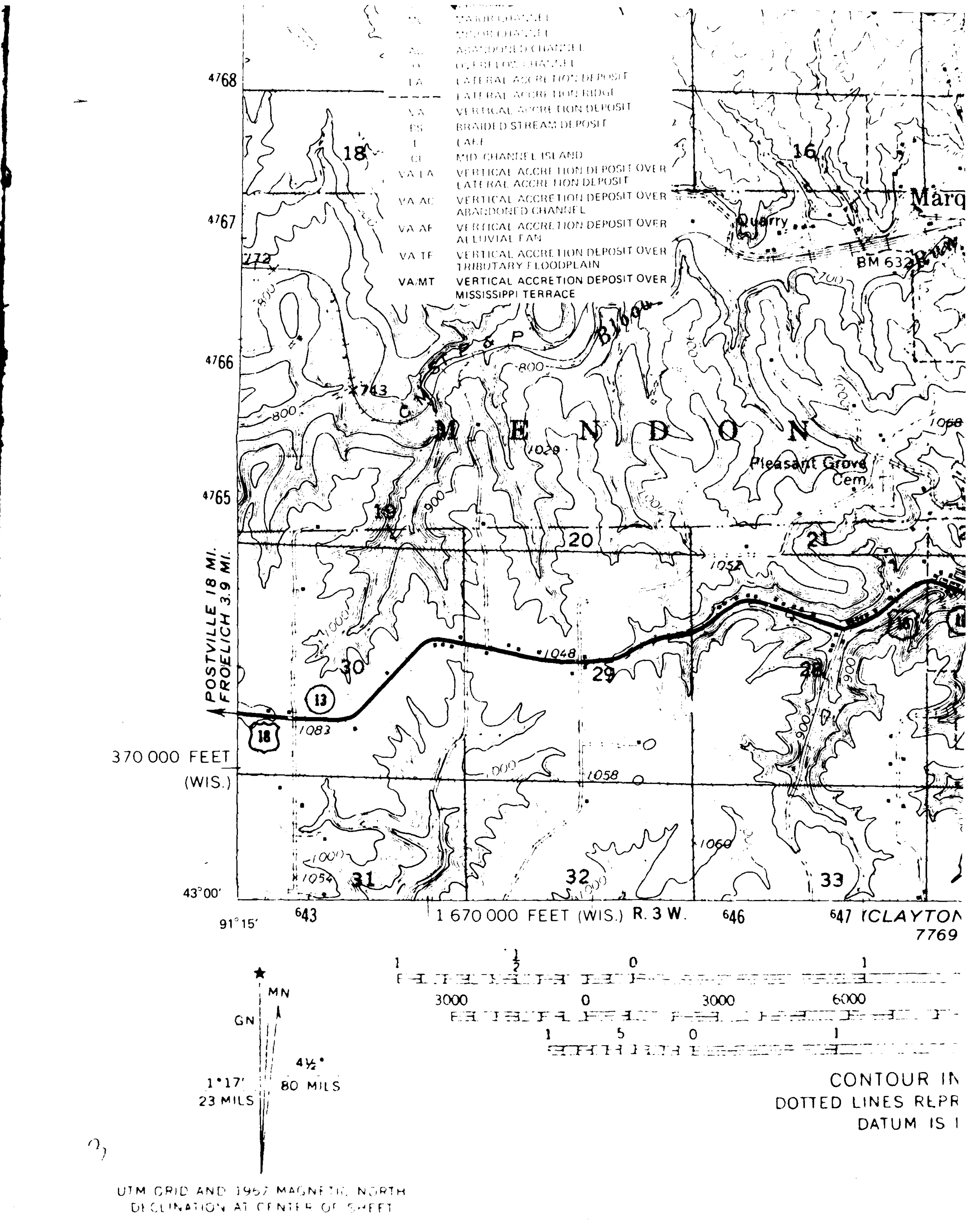
GEOMORPHOLOGY OF POOL 10
PRAIRIE DU CHIEN SE
PLATE 4



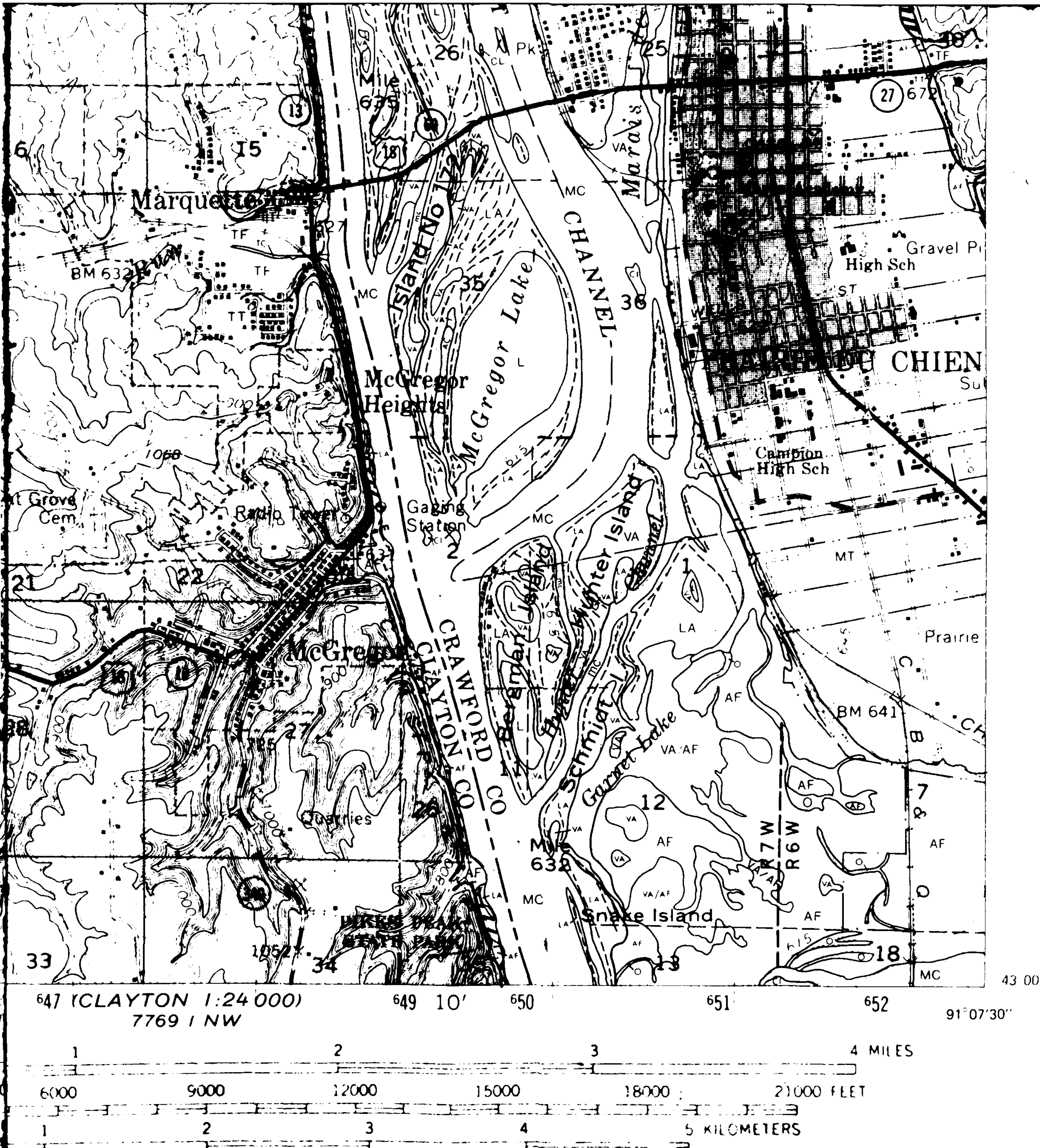
91 15'
43 07'30"
4775
4774
4773
4772
5'
T. 96 N.
T. 95 N.
4770
4769
4768
YELLOW
RIVER
Dousman
Creek
YRSF
YRSF
YRSF
EFFIGY MOUNDS NATIONAL MONUMENT
ALLAMAKEE CO
CLAYTON CO
96 N
95 N
BM 1137
1039
BM
956
Cem
939
635
629
657
1067
969
1094
1113
19
20
21
22
28
29
30
31
32
33
4
5
6
7
9
10
TF
TF
TT
LEGEND
VALLEY WALL
COLLUVIAL SLOPE
TT TRIBUTARY TERRACE
TF TRIBUTARY FLOODPLAIN
TC TRIBUTARY CHANNEL
AF ALLUVIAL FAN
MT MISSISSIPPI TERRACE
MC MAJOR CHANNEL
MINOR CHANNEL
ABANDONED CHANNEL
OVERFLOW CHANNEL
LATERAL ACCRETION DEPOSIT



91 07'30"
43 07'30"
BM 1137
1039
Mile 640
T8N
T7N
Cem
956
MC
MISSISSIPPI
RIVER
ISLAND
Spring
BM 632
Mill
K
AC
Lake
Gremore
UPPER MISSISSIPPI
NATIONAL MONUMENT
EFFIGY MOUNDS
939
Island No 167
635
CRAWFORD CO
Marais Lake
Upper Marais
96N
95N
Limery
650
656
MT
VA/MT
Island No 170
Gravel Pits
St Feriol
Radio Tower (WPRE)
EAST
629
Radio
Pk



ABANDONED CHANNEL
LA LATERAL ACCRETION DEPOSIT
LATERAL ACCRETION RIDGE
VA VERTICAL ACCRETION DEPOSIT
BS BRAIDED STREAM DEPOSIT
L LAKE
CI MID CHANNEL ISLAND
VA LA VERTICAL ACCRETION DEPOSIT OVER LATERAL ACCRETION DEPOSIT
VA AC VERTICAL ACCRETION DEPOSIT OVER ABANDONED CHANNEL
VA AF VERTICAL ACCRETION DEPOSIT OVER ALLUVIAL FAN
VA TF VERTICAL ACCRETION DEPOSIT OVER TRIBUTARY FLOODPLAIN
VA/MT VERTICAL ACCRETION DEPOSIT OVER MISSISSIPPI TERRACE
4768
4767
4766
4765
18
16
Quarry
BM 632
Bloody
CM St P & P
MENDON
Pleasant Grove Cem
19
20
21
29
30
28
31
32
33
POSTVILLE 18 MI.
FROELICH 3.9 MI.
13
18
1083
1048
1052
1058
1060
1054
1029
743
370 000 FEET (WIS.)
43°00'
91°15'
643
1 670 000 FEET (WIS.) R. 3 W.
646
647 (CLAYTON
7769
MN
GN
4½°
80 MILS
1°17'
23 MILS
UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
CONTOUR IN
DOTTED LINES REPR
DATUM IS

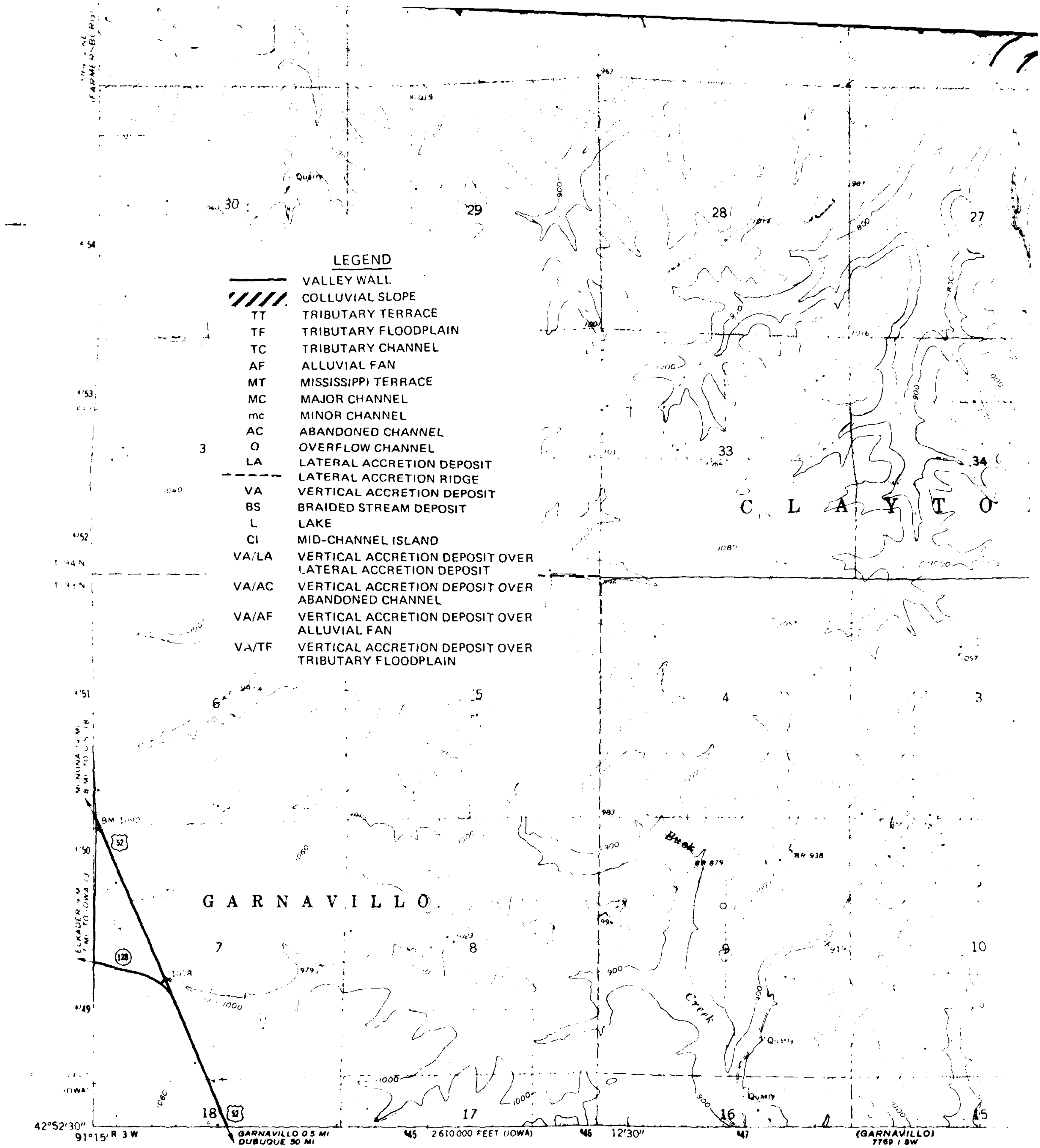


CONTOUR INTERVAL 20 FEET
TED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

GEOMORPHOLOGY OF POOL 10
PRAIRIE DU CHIEN SW
PLATE :

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CLAYTON QUADRANGLE
IOWA – WISCONSIN
7.5 MINUTE SERIES (TOPOGRAPHIC)



(LITTLEPORT)
7769 IV SE

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Topography by photogrammetric methods from aerial photographs taken 1958. Field checked 1962

Polyconic projection. 1927 North American datum
10,000-foot grids based on Iowa coordinate system, north zone, and Wisconsin coordinate system, south zone
1000-metre Universal Transverse Mercator grid ticks, zone 15, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

MN
GN
1°14'
22 MILS
4½°
80 MILS

UTM GRID AND 1962 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOU
NATIONAL GEODETIC VERTICAL DATUM OF 1

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225,
AND BY THE IOWA GEOLOGICAL SURVEY, IOWA CITY
AND BY THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVE
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AV

SCALE 1 24 000

1 MILE

1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETRE

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
GICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
HE IOWA GEOLOGICAL SURVEY, IOWA CITY, IOWA 52240
EOLOGICAL AND NATURAL HISTORY SURVEY, MADISON, WISCONSIN 53706
BING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

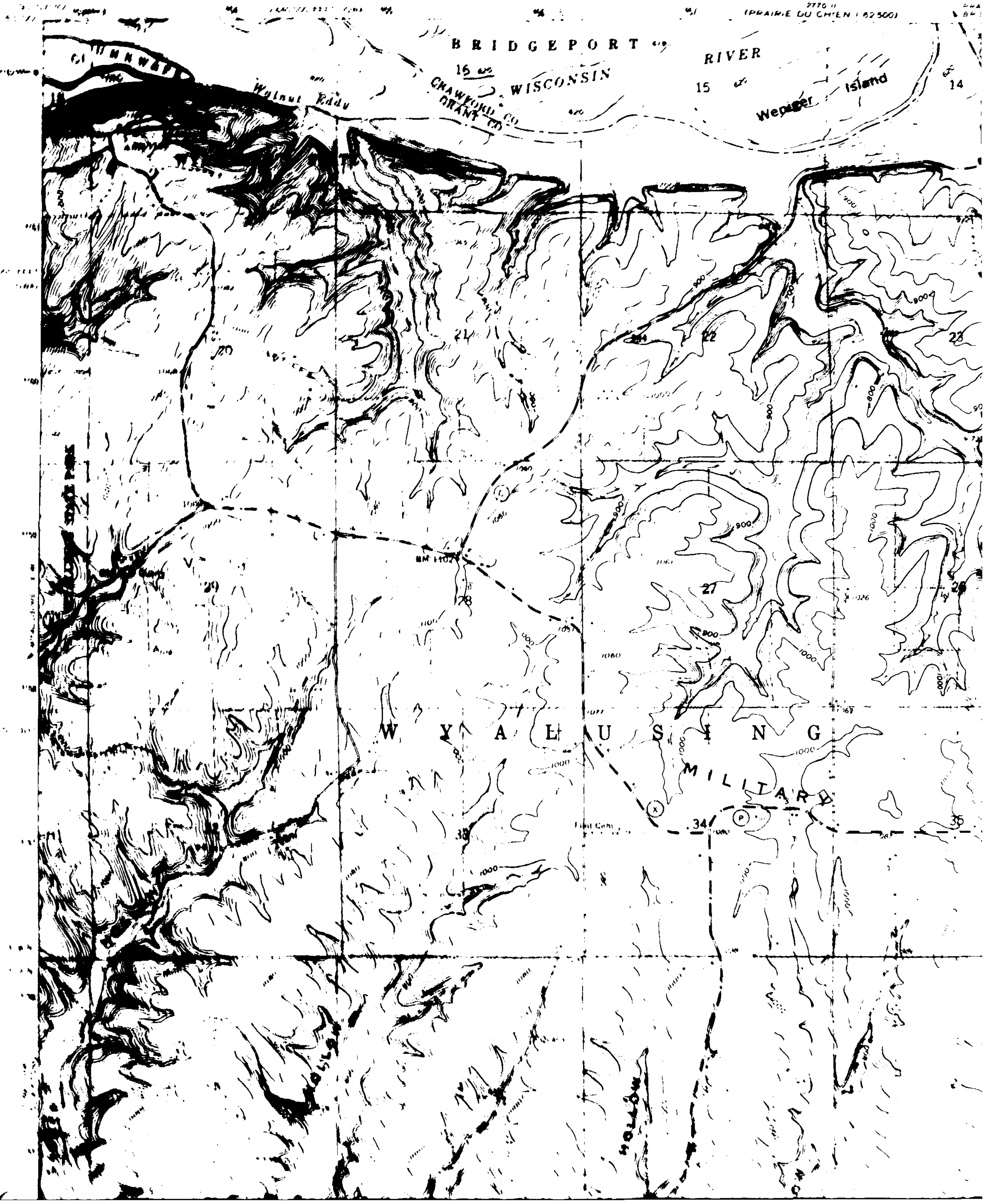
QUADRANGLE LOCATION

ROAD CLASSIFICATION

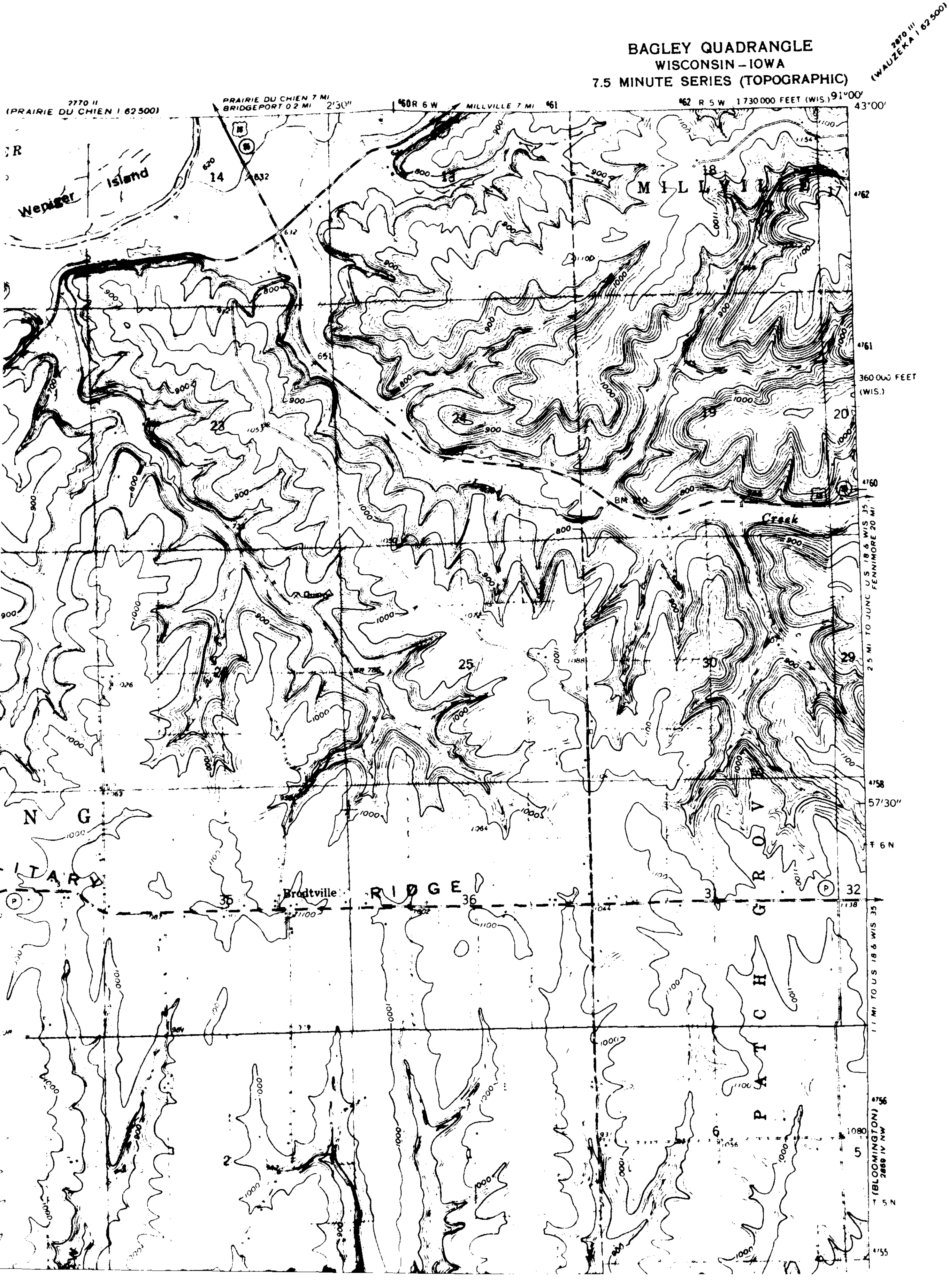
Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U.S. Route — State Route

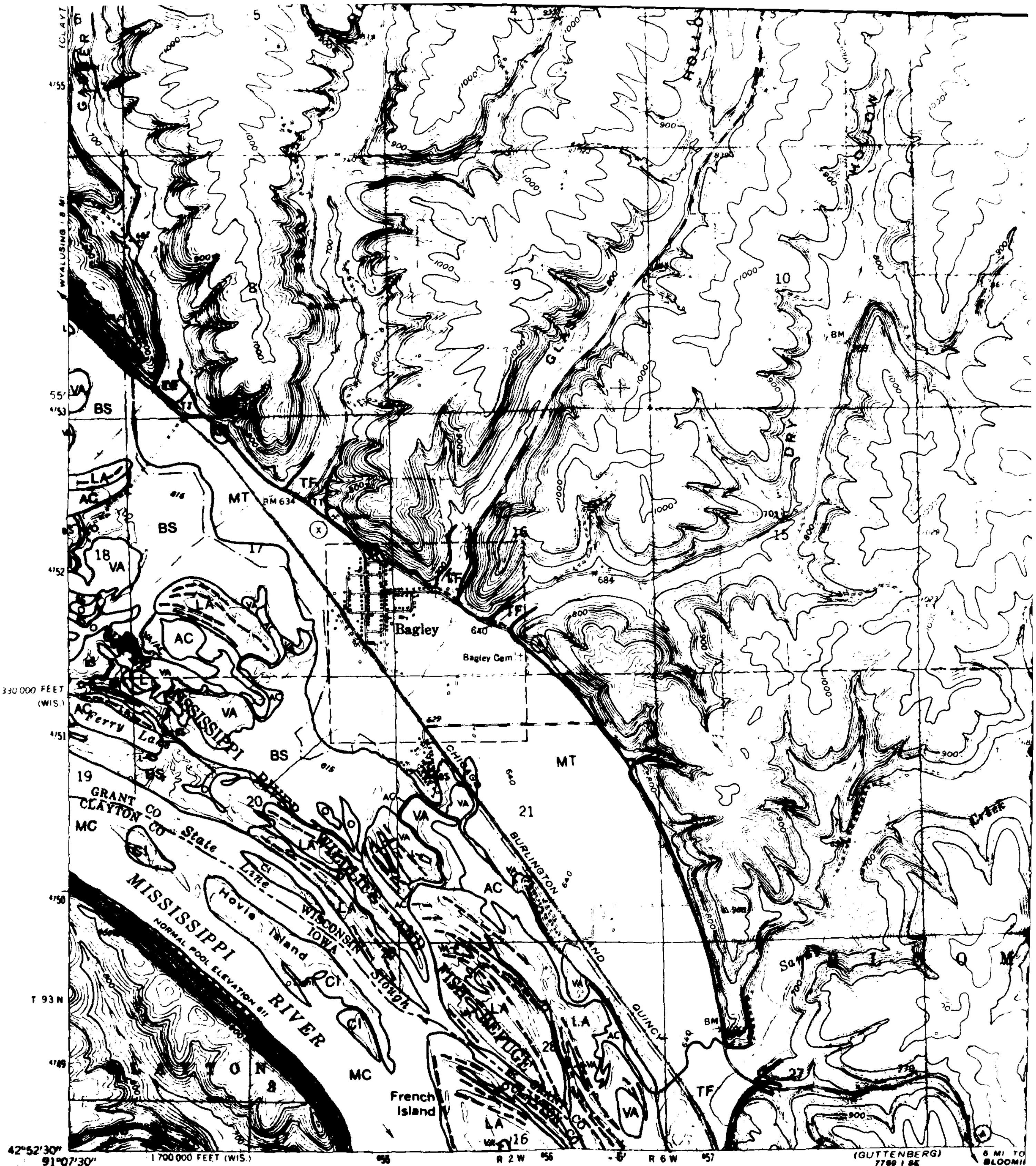
GEOMORPHOLOGY OF POOL 10
CLAYTON
PLATE 5

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



BAGLEY QUADRANGLE
WISCONSIN - IOWA
7.5 MINUTE SERIES (TOPOGRAPHIC)





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Topography by photogrammetric methods from aerial photographs taken 1958. Field checked 1962

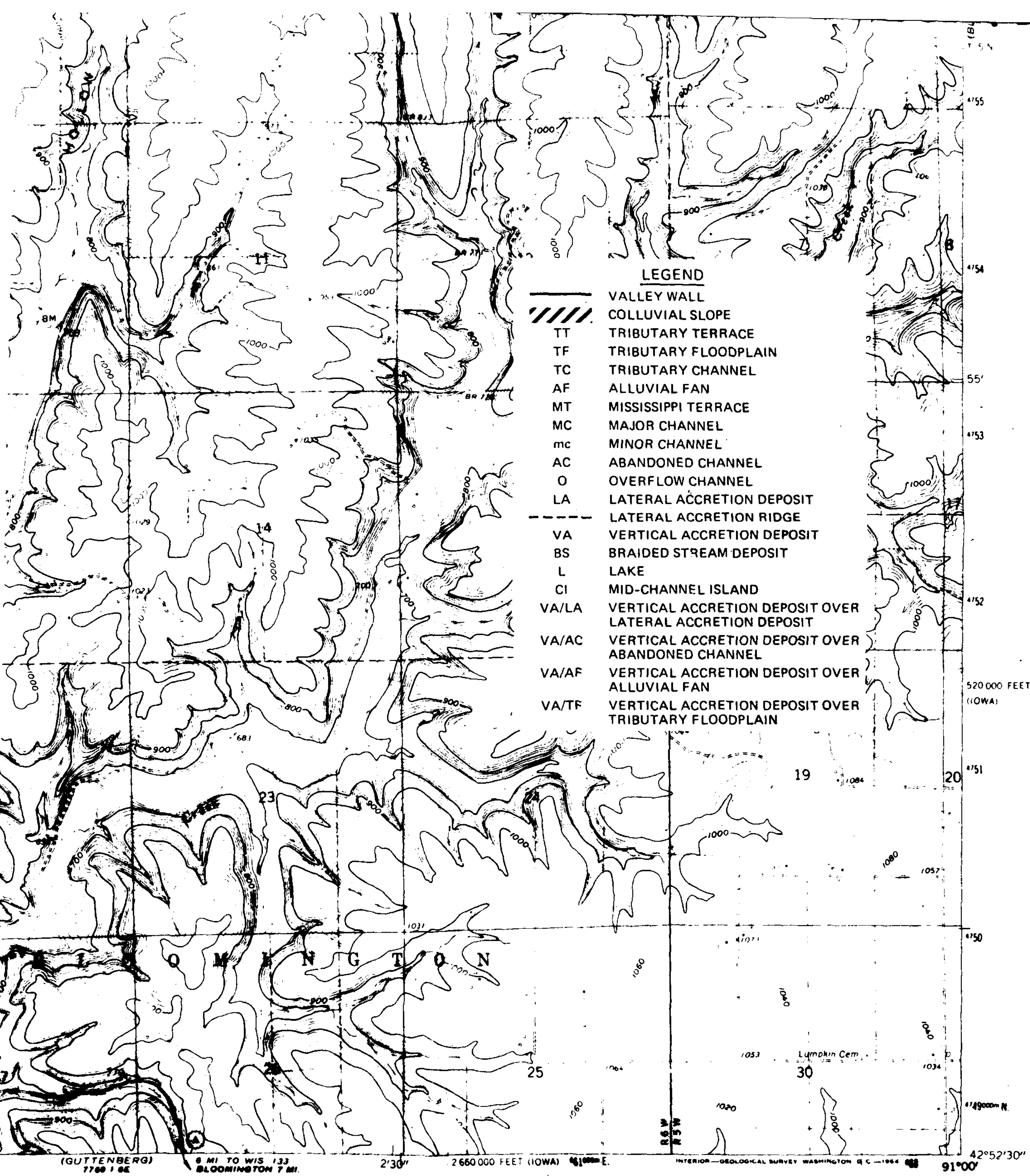
Polyconic projection. 1927 North American datum
10,000-foot grids based on Wisconsin coordinate system, south zone and Iowa coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 15, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1962 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STA

FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER 25, COLORADO O
THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, M
AND BY THE IOWA GEOLOGICAL SURVEY, IOWA CI
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAI



SCALE 1 24 000

1 MILE

7000 FEET

1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
CAL SURVEY, DENVER 25, COLORADO OR WASHINGTON 25, D. C.
CAL AND NATURAL HISTORY SURVEY, MADISON 6, WISCONSIN
E IOWA GEOLOGICAL SURVEY, IOWA CITY, IOWA
TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

WISCONSIN

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Medium-duty Light-duty

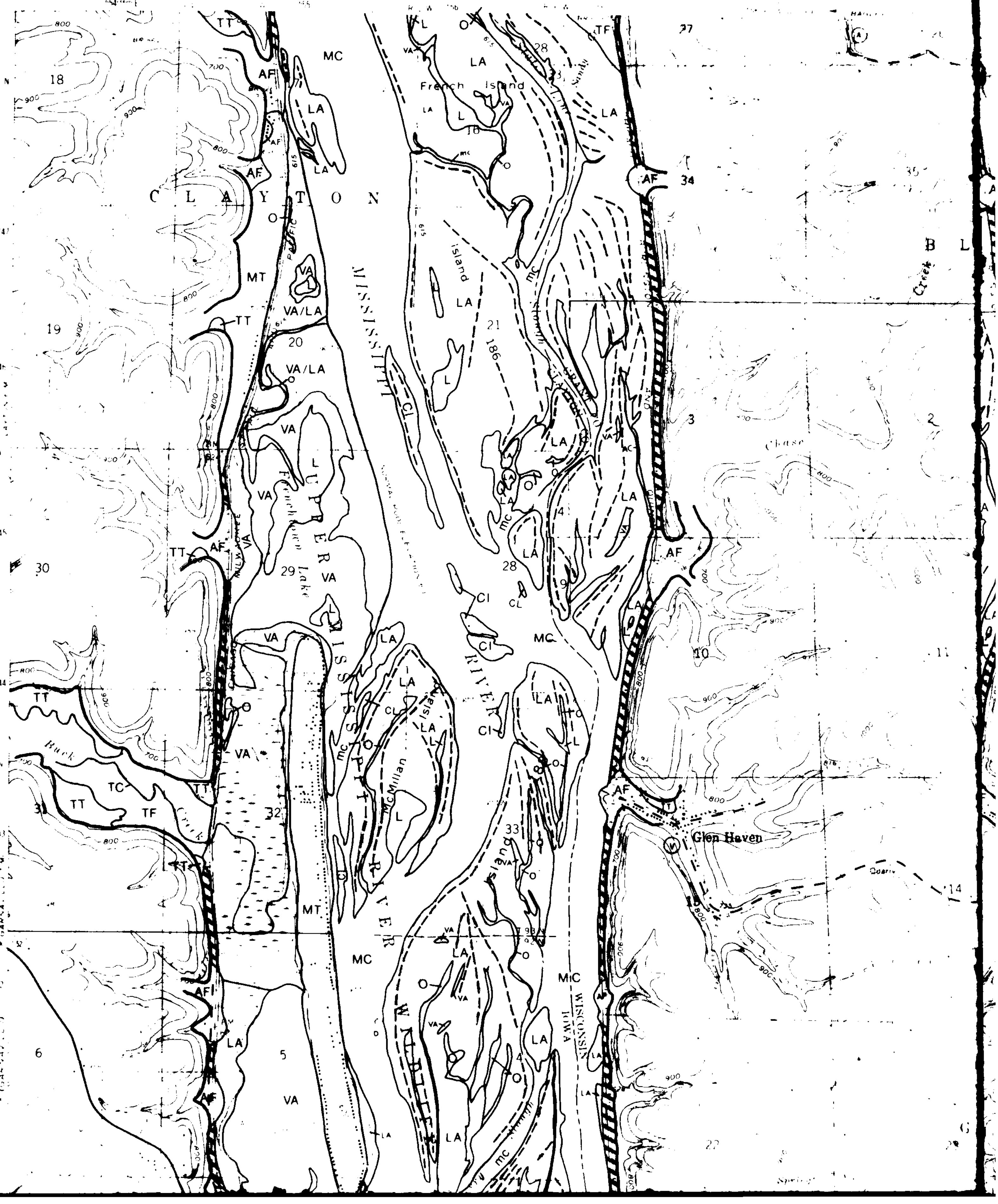
Unimproved dirt

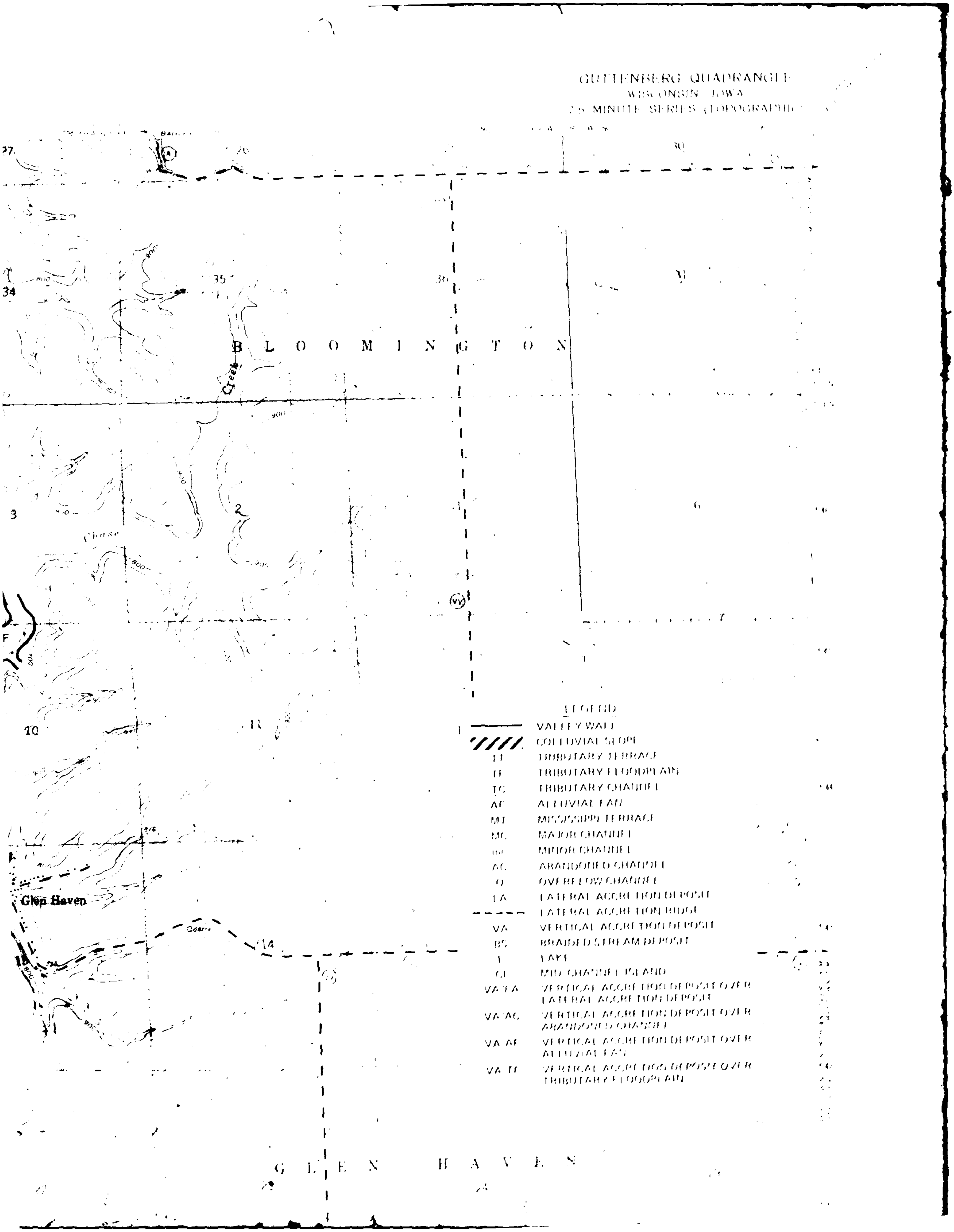
U. S. Route State Route

(BEETOWN)

GEOMORPHOLOGY OF POOL 10
BAGLEY
PLATE 6

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY




GUTTENBERG QUADRANGLE
WISCONSIN - IOWA
7.5 MINUTE SERIES (TOPOGRAPHIC)
B L O O M I N G T O N
Creek
Glen Haven
G L E N H A V E N
LEGEND
VALLEY WALL
COLLUVIAL SLOPE
TT TRIBUTARY TERRACE
TF TRIBUTARY FLOODPLAIN
TC TRIBUTARY CHANNEL
AF ALLUVIAL FAN
MT MISSISSIPPI TERRACE
MC MAJOR CHANNEL
mc MINOR CHANNEL
AC ABANDONED CHANNEL
O OVERFLOW CHANNEL
LA LATERAL ACCRETION DEPOSIT
LATERAL ACCRETION RIDGE
VA VERTICAL ACCRETION DEPOSIT
BS BRAIDED STREAM DEPOSIT
L LAKE
CI MID CHANNEL ISLAND
VA/LA VERTICAL ACCRETION DEPOSIT OVER LATERAL ACCRETION DEPOSIT
VA/AC VERTICAL ACCRETION DEPOSIT OVER ABANDONED CHANNEL
VA/AF VERTICAL ACCRETION DEPOSIT OVER ALLUVIAL FAN
VA/TF VERTICAL ACCRETION DEPOSIT OVER TRIBUTARY FLOODPLAIN

(COLESBURG) 7769 II NW

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Topography by photogrammetric methods from aerial photographs taken 1958. Field checked 1962

Polyconic projection. 1927 North American datum
10,000 foot grids based on Wisconsin coordinate system, south zone and Iowa coordinate system, north zone
1000 meter Universal Transverse Mercator grid ticks, zone 15, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1962 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

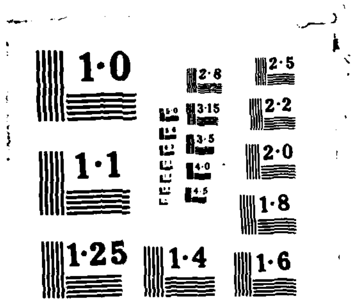
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDA

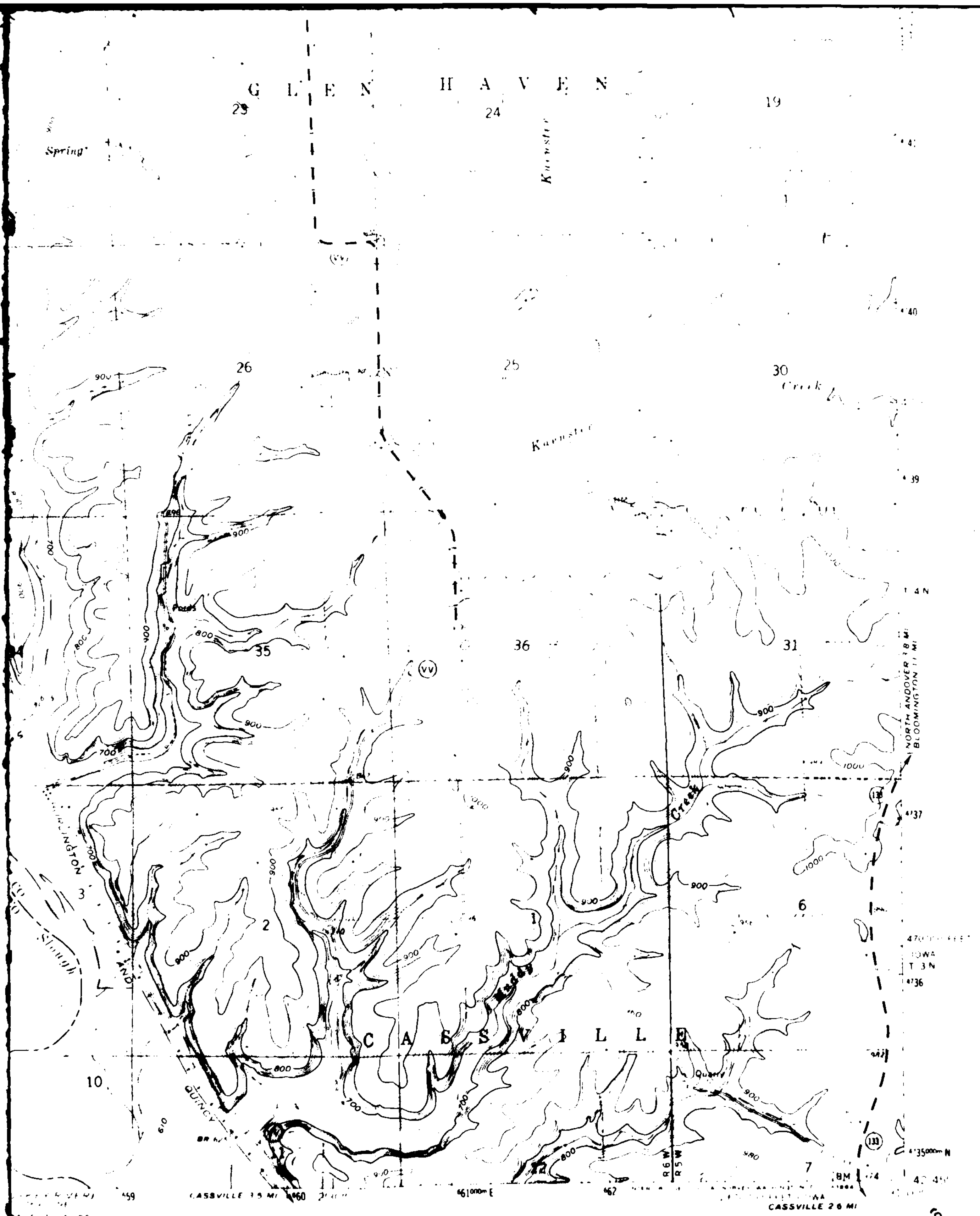
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER 25, COLORADO OR
THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, MA
AND BY THE IOWA GEOLOGICAL SURVEY, IOWA CITY,
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILAB

AD-A167 935 THE ARCHAEOLOGICAL POTENTIAL OF POOL NUMBER 10 UPPER MISSISSIPPI RIVER: A.. (U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS GEOTE.. P E CHURCH 2/2

UNCLASSIFIED 15 MAR 84 F/G 8/6 NL

END
DATE
FILMED
6 86


1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
1·1
4·5
1·8
1·25
1·4
1·6



ALE 1:24 000

0 — 1 MILE

3000 4000 5000 6000 7000 FEET

0 — 1 KILOMETER

INTERVAL 20 FEET
FFERENT 5 FOOT CONTOURS
IS MEAN SEA LEVEL

NATIONAL MAP ACCURACY STANDARDS
, DENVER 25, COLORADO OR WASHINGTON 25, D. C.
TURAL HISTORY SURVEY, MADISON 6, WISCONSIN
LOGICAL SURVEY, IOWA CITY, IOWA
C MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U S Route — State Route

WISCONSIN
QUADRANGLE LOCATION

GEOMORPHOLOGY OF POOL 10
GUTTENBERG
PLATE 7

END

DATE

FILMED

6-86

DTIC